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† In marine separate.

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THE YEAR 1816—THE CAUSES OF ABNORMALITIES[1]

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SYNOPSIS

The year 1816 is famous from the meteorological point of view. More has been written about this year than any other. All the older books on climate and weather and many biographies and histories have something to say about it. There are many references to it in the periodical literature but the statements are often inaccurate and exaggerated.

Good observations were made in Williamstown, Mass., from 1816 to 1838. The observations for 1816 as compared with those from 1816 to 1838 and from 1901 to 1923 are discussed. The year 1816 was the seventh coldest, averaging 44.3° F. or 1.3° F. below normal. The two coldest years (1816–1838) were 1836 and 1837, each averaging 42.6° F., or just 3° F. below normal. Thus 1816 as a whole was not record-breakingly cold. February, October, November, and December of 1816 were too warm, while the remaining months were much too cold. The year was thus exceptional because of a very cold summer. The lowest temperatures at 7 a. m. for June, July, and August, 1816, were 35° F., 43° F., and 37.5° F., respectively, and these were the lowest for these months for the 23-year period. The individual cold spells during the summer months are discussed next and the observations taken at other stations during 1816 are compared with those at Williamstown

In the second part the possible reasons why 1816 was so abnormal are treated. There had been the violent volcanic eruption of Tomboro in April, 1815. A weak sun-spot maximum had also occurred during 1816.

In the third part the possible causes of the abnormality of any month or year are discussed. Volcanic eruptions, changes in the activity or condition of the sun (sun spots, solar constant), changes in the surface temperatures of the oceans, changes in the composition of the atmosphere (ozone, carbon dioxide), and accidental causes are treated in order.

PART I

The year 1816 is famous from the meteorological point of view. More has probably been written and said about this year than any other. It is famous as *the* cold year and is often called "the year without a summer," "poverty year," or "eighteen hundred and froze to death."

All the older books on meteorology, climate, or weather have much to say about it. Take as an example Blodget's Climatology of the United States published in Philadelphia in 1857. Data concerning the year are found in many tables and there are many references to it. On pages 147 and 148 there are these comments: "But during this period the most remarkable depressions of temperature in the summer months known to all history of thermometer measurements occurred in the period from 1811 to 1817. Of these 1812 and 1816 were the coldest. In the Northern States snows and frosts occurred in every month of both summers; Indian corn did not ripen, fruits and grains of every sort were greatly reduced in quantity, or wholly cut off. * * * In England 1816 was almost as extreme as in the United States."

Most of the biographies and histories (particularly State and local histories) covering this period also have something to say about this year 1816. Take for example Chauncy Jerome's History of the American Clock Business for the past Sixty Years and Life of Chauncy Jerome. This was written in 1860 when Jerome was 67 years old. He was thus 23 years old in 1816. On pages 31 and 32 he has something to say about the famous year. He was then living in Plymouth, Conn.

> The next summer was the cold one of 1816, which none of the old people will ever forget, and which many of the young have heard a great deal about. There was ice and snow in every month in the year. I well remember the 7th of June, while on my way to work, about a mile from home, dressed throughout with thick woolen clothes and an overcoat on, my hands got so cold that I was obliged to lay down my tools and put on a pair of mittens which I had in my pocket. It snowed about an hour that day. On the 10th of June, my wife brought in some clothes that had been spread on the ground the night before, which were frozen stiff as in winter. On the 4th of July I saw several men pitching quoits in the middle of the day with thick overcoats on, and the sun shining bright at the time. * * * Not half enough corn ripened that year to furnish seed for the next.

Jerome is usually quite accurate in his statements and free from exaggeration so this can probably be taken at almost face value although written from memory 44 years after the event.

Thompson in his History of Vermont says: "It is universally conceded that the year 1816 was the coldest ever known in Vermont."

There are also many casual references to this year in the periodical literature all the way from 1816 to date. In fact references seem to be more frequent during the last few years. If any month is at all cold, the year 1816 is at once recalled as the awful example. The Literary Digest for September 6, 1924, contains this:

> In 1816 there were no crops raised north of the Ohio and Potomac and but scanty returns much farther south. Frost, snow, and ice appeared in every month of spring, summer, and fall.

That is plainly somewhat exaggerated.

If all the statements in climatologies, in books on the weather, in biographies, in histories, and in the periodical literature were collected, they would form a sizable volume. They would not, however, be particularly valuable unless subjected to a very close scrutiny as there are many inaccurate and exaggerated statements. The statements quoted are good examples of what is found.

Fortunately meteorological observations were commenced in Williamstown, Mass., on January 1, 1816. The temperature was noted three times a day at 7 a. m., 2 p. m., and 9 p. m. The amount of precipitation, the wind direction, and the character of the day were also noted, and there were many comments. There were no maximum and minimum thermometers so the highest and lowest temperatures were not recorded and the barometric pressure was also not observed that year. It is interesting to note that the moon's age was very carefully recorded. That was discontinued, however, after eight or nine years. Meteorological observations have been

[1] Annual presidential address read before the American Meteorological Society at Washington, D. C., Dec. 31, 1924.

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continued in Williamstown to date, so that the record is now 109 years long. For the first 23 years, that is, from 1816 to 1838, inclusive, the observations were made with great care, they are apparently uniform, there are no breaks, and they have been carefully averaged. These observations will thus serve to show how abnormal the year 1816 was as compared with the 23 years from 1816 to 1838. Williamstown is also well located for a critical study of the year 1816. It is not near the sea. Taking New York and New England together, it is approximately centrally located.

The observations in 1816 were taken within a few hundred feet of the Hopkins Observatory of Williams College which was built in 1838. It is not known just what kind of a shelter or what instruments were used. The observations for 1816 to 1838 were bound up in book form, probably before 1850, and that has kept them intact until the present time.

Table 1 contains the average monthly and the average yearly temperatures for the 23 years, 1816 to 1838, inclusive. The normals for the months and the year, determined by averaging the 23 corresponding values are also given. The exponent 3 indicates the lowest average and the exponent 2 the next lowest. The exponent 3 indicates the highest mean. It will be seen that the normal yearly temperature for the 23 years comes to 45.6° F. The two coldest years were 1836 and 1837, each with an average of 42.6° F., and thus just 3° F. below normal. The year 1816 averaged 44.3° F. or 1.3° below normal, and was only the seventh coldest. Thus the year 1816 was not phenomenal because the year as a whole averaged so low. The years 1836 and 1837, which are but seldom mentioned, were much worse. When the individual months are considered, it will be noted that February, October, November, and December were too warm while the remaining months were too cold. May was the second coldest for the 23 years and averaged 3.8° F. below normal; June was the second coldest for 23 years and averaged 5.2° F. below normal; July was the coldest for 23 years and averaged 5.4° F. below normal; August averaged 2.1° F. below normal and September averaged 3.9° F. below normal. The reason why 1816 is considered to be so abnormal begins to be apparent. It is because the three summer months June, July, and August, and the two adjacent months, May and September, were all far below normal. And yet these departures from normal are not extremely large and only one was the largest for 23 years. If the cold months had not been consecutive, or if the cold spell had come during the winter, spring, or autumn instead of midsummer, the year 1816 would never have been famous. It is also to be noted that the summer of 1837 with the same five months, 4.7°, 2.6°, 3.5°, 2.1°, and 2.4° below normal, was almost as bad, and yet 1837 is seldom heard of.

The reason why 1816 was considered so abnormal becomes still more apparent when the lowest observed temperatures during each of the summer months for the 23 years are tabulated. These are indicated in Table 2. It must be remembered that these are not minimum temperatures but temperatures observed at 7 a. m. or 9 p. m. It will be noted that the lowest temperatures for all three months came in 1816. During June a temperature of 35° was noted; during July 43°, and during August 37.5°. These were all 7 a. m. temperatures. One naturally wonders how low the minimum temperatures were. There are two ways of getting at this. In the first place, in some places in the observation book the sunrise temperature was given along with the 7 a. m. temperature if it was particularly low. All these cases have been indicated. The average difference is between 3 and 4 degrees. Secondly, Table 3 gives for Albany, N. Y., the average difference for the three summer months, June, July, and August, between the minimum and the 7 a. m. temperatures for the last 10 years, 1915 to 1924, inclusive. It will again be seen that the minimum temperatures should have been around 4 degrees lower than the 7 a. m. temperatures. That means that it froze every month during the summer of 1816, since the minimum temperatures were probably about 31°, 39°, and 33°, and 39° is the frost limit for Williamstown.

The marginal comments in the observation book in connection with these three low temperatures and a description of the famous cold spells are next in order. The famous cold spell during June and, in fact, the most remarkable during the summer, came from the 5th to the 11th. On June 5 at noon the temperature was 83° F. Thunder showers came quickly and the wind shifted into the northwest with vigor. In fact, it was cloudy and squally and the temperature was forced steadily down. On the 6th at 7 a. m. the temperature was 45¼° F., and that was *warmest* for the day. The marginal comment says: "Snowed several times—in Peru the ground was white—also in Cheshire, Windsor, and west of us on mountains." Jerome's comment on this same day at Plymouth, Conn., will also be recalled. He said: "It snowed about an hour that day." Zadock Thompson, in his History of Vermont, published in 1842, says: On the 8th of June snow fell in all parts of the State, and upon the highlands and mountains to a depth of 5 or 6 inches." There seem to have been snow squalls over a large part of New England. The date is not quite the same, but that is probably a lapse of memory. At 7 a. m. on the 7th the temperature was down to 35° F. As the wind was still blowing and there were some clouds, it is a question if the minimum temperature had been much lower. The wind continued steadily in the northwest and the 7 a. m. temperature on the 8th was 40.5° F., on the 9th, 40.5° F., on the 10th, 40⅔° F., and on the 11th, 38° F. The culmination evidently came in the early hours of the 11th. The marginal comment says: "Heavy frost—vegetables killed—at 5 o'clock, temperature 30.5°." By 7 a. m. the wind was south, the temperature 38°, and rapidly rising.

All this can only be interpreted in terms of an extensive area of high pressure which was ushered in by strong northwest winds and snow squalls, and dominated the weather for six full days. This was the only cold spell during June, the rest of the temperatures being quite moderate. In fact, on the 24th the temperature was up to 94° F., which is very high for Williamstown. In July the same thing took place on a more moderate scale. On the 6th the wind shifted to the northwest with vigor and the temperature was forced steadily downward. This time it lasted four days, and the lowest temperature was 43° F. at 7 a. m. on the 9th. The single marginal comment is "frost." There was no snow this time. The rest of July was again very seasonable. During August there was no pronounced cold spell. The lowest temperature was 37.5° F. at 7 a. m. on the 29th. The marginal comment is "Severe frost—some vegetables (green corn) killed—few solar spots." It is interesting to note that solar spots and a change in the phase of the moon were being carefully observed. It was apparently considered at the time that these two things were the chief causes of abnormal weather. Thus the chief abnormality of the summer consisted of these three cold spells. It snowed during the cold spell in June only. It barely froze in July.

The average temperature for the different months and the years were computed, using the 7 a. m., 2 p. m., and 9 p. m. temperatures. In fact, they were computed from daily temperatures which were found by the formula ⅓ (7 a. m. + 2 p. m. + 9 p. m.). The formula ¼ (7 a. m. + 2 p. m. + 9 p. m. + 9 p. m.) is considered much better and was used for a time by the United States Weather Bureau. Now, of course, ½ (max. + min.) is always used to compute an average daily temperature. These differ, however, but little from each other. Table 4 gives the average monthly temperatures for 1816 when the daily temperatures were computed by both formulæ. It will be seen that the average difference is 0.65° F. The summer difference is a little less than a degree, and the winter difference about four-tenths of a degree. The difference between average monthly temperatures when the daily temperatures are computed by ¼ (7 a. m. + 2 p. m. + 9 p. m. + 9 p. m.) and from ½ (max. + min.) has often been investigated, and the difference is only a few tenths of a degree. Thus the values given in the table for the various months and for the years 1816 to 1838 are only a few tenths of a degree higher than if the daily temperatures had been computed from ½ (max. + min.).

Corresponding data for the last 23 years (1901 to 1923, inclusive) will be of interest. In Table 5 are given the average yearly temperatures for the 23 years 1901 to 1923, inclusive. The normals are also given. The normal yearly temperature for 1901 to 1923 comes out 45.52° F., while the normal yearly temperature for 1816 to 1838 comes out 45.57° F. And this in spite of the fact that the first is computed from ½ (max. + min.) while the last rests upon ⅓ (7 a. m. + 2 p. m. + 9 p. m.). The departures of the coldest May, June, July, August, and September from normal are 8.3°, 4.2°, 2.8°, 5.4°, and 3.7°. The departures of the same five months of 1816 from normal were 3.8°, 5.2°, 5.4° 2.1°, and 3.9°. These are of the same order of magnitude. Thus summer months have departed from normal just as much or more during the last 23 years as in the months of 1816, only the big departures did not all come in the same year.

Table 6 contains the lowest minimum temperature for June, July, and August for the years 1901 to 1923, inclusive. The very lowest values are 35° F. for June 1912, 41° F. for July 1912, and 35° F. for August 1904. These are minimum temperatures. Compare them with 7 a. m. temperatures of 35° F. for June 1816, 43° F. for July, and 37.5° for August. The 1816 minimum temperatures were thus probably lower by a very few degrees only than the lowest observed from 1901 to 1923, inclusive.

The agreement of Williamstown observations with those taken at other stations during 1816 is a matter of importance. Temperature observations were begun in North America perhaps as early as 1730 or 1740. Very often they were continued at a station only a year or two. It is hard to say at just how many stations observations were being made during 1816—at certainly less than 10 stations. Blodget, in his climatology, gives the departure from normal of the various months of 1816 for four places, namely, Salem, Cambridge, New Bedford, and Williamstown. These, with the New Haven values which are not included, are given in Table 7. Williamstown was included but these values have been put in parenthesis since the normals were based on only a few years, 1816–1819. The values derived from the normals based on the years 1816–1838 are given instead. When these are used it will be seen that the agreement among all five stations is good.[1] The departure from normal was practically the same over all the northeastern part of the United States. The lowest temperatures observed at New Bedford during June, July, and August, 1816, were 38°, 50°, and 48°, respectively. These are apparently minimum temperatures. It is interesting to compare them with the three lowest 7 a. m. temperatures at Williamstown which were 35°, 43°, and 37.5°, respectively. The normal annual temperature (1816–1838) at New Bedford is 48.6°, while at Williamstown the (1816–1838) value is 45.6°, just 3° F. lower. Williamstown was thus harder hit by the cold than New Bedford, which one would expect from the latter's location near the sea.

Thus as summary it may be stated that 1816 was a phenomenal year *not* because the year as a whole averaged so low, *not* because each month of the year was uniformly cold, but because the three summer months and the two adjacent ones were all cold, and chiefly because the lowest temperatures were extremely low in a locality where the difference of a very few degrees in the lowest temperature during the summer months makes all the difference between a severe frost and the absence of frost.

PART II

Why was 1816 so abnormal? It is easy to ask questions but not so easy to answer them. The year 1816 belongs to that famous group of six years, 1812 to 1817, inclusive, all of which were cold over the whole world. According to Prof. William J. Humphreys as given in his masterly book, Physics of the Air, the world as a whole during 1816 was 0.90° C. or 1.62° F. below normal. When we say the whole world was cold, of course we mean the average departure from normal of the stations considered was 1.62° F. The vast oceans were without stations and there were also great land areas without stations as well, nevertheless, the stations considered were as typical of the whole earth as possible. According to Humphreys, these cold years were caused largely, if not entirely, by volcanic eruptions which put dust into the upper atmosphere. This idea is fully elaborated in the book just mentioned. In a crude form the idea may have originated with Benjamin Franklin, or even earlier, as Humphreys himself says. This volcanic dust in the upper atmosphere is much more efficient in shielding the earth from the sun's ether waves than in retaining the radiation from the earth and thus acts to keep the earth cool. There was an eruption of Soufrière, St. Vincent, April 30, 1812, and of Mayon, Luzon, in 1814. The chief volcanic eruption, however, was that of Tambora, Sumbawa, April 7 to 12, 1815.

This was a really great eruption and ranks with the four or five largest during the last two centuries. It is estimated that from 37 to 100 cubic miles of dust, ashes, and cinders were thrown into the atmosphere. Some 60,000 people lost their lives. For three days there was darkness at a distance of 300 miles and the explosions were heard at a distance of nearly a thousand miles. In Williamstown it will be remembered that the year 1816 was 1.3° F. below normal, and Table 8 contains the departure from normal of the various months for both 1816 and 1817. During the period 1816 to 1838 there was another group of particularly cold years the world over. These were 1835, 1836, 1837, and 1838. In Williamstown the years 1836 and 1837 averaged the coldest (3° F. below normal) of any years during the period. The de-

[1] Observations of some value were probably made during 1816 at Castine, Me.; Sharon, Conn.; Deerfield, Mass.; and Philadelphia.

partures of the various months of these years from normal are also given in Table 8. The great eruption of Cosequina, Nicaragua, had occurred on January 20, 1835. During the last 23 years (1901 to 1923) The greatest volcanic eruption was that of Katmai, Alaska, June 6, 1912, which caused the earth as a whole to average 0.54° below normal. The average monthly temperature in Williamstown hardly shows this, however. The departures from normal for this year and 1913 are given in Table 8. The cold months in 1912 came before the eruption. It is very remarkable, however, that the lowest minimum temperatures, as indicated in Table 6, all come during 1912 and 1913. It is dangerous to generalize from a few observations, but two conclusions seem fairly well established. In the first place, during the two or three years which follow a volcanic eruption which may cause the temperature of the earth as a whole to be, say, 1° F. below normal, it is impossible to say just which months, if any, are going to be below normal at a particular station. And secondly the chief effect of a volcanic eruption seems to be to cause the minimum temperature, especially of the summer months, to be particularly low.

But to return to the original question, is there any other known reason why 1816 should have been so abnormally cold? A sun-spot maximum occurred during 1816. To be sure it was a poorly marked maximum since the Wolfer sun-spot number was about 45 for the year. It will be remembered that these numbers vary from practically 0 during a minimum to perhaps 150 during a sharply-marked prominent maximum. The earth as a whole is supposed to be perhaps 0.5° F. colder than normal during a sun-spot maximum.

PART III

We can now leave the year 1816 and raise the general question. If any particular year or month is abnormal, what are the possible reasons for the abnormality? When this question has been satisfactorily answered, a long step has been taken toward being able to predict the characteristics of a month a considerable time in advance. This is a very practical problem and the pressure for its solution is great.

A *first* possible cause is one that has already been considered in connection with the year 1816, namely, dust thrown into the upper atmosphere by violent volcanic eruptions. The four or five more violent eruptions which have occurred during the last century and a half seem to have lowered the temperature of the whole earth about 1° F. on the average. It must be emphasized also that at any particular station it is impossible to state just what months during the two or three years following a violent eruption are going to be below normal, and how much. This means that there are other causes of abnormality which are far more powerful than volcanic dust.

A *second* cause is the changes in the activity or condition of our sun. The solar constant and the sun spots are the two indices of solar activity which are being critically and constantly observed at present and about which we know most. There is a growing tendency at present to ascribe all abnormalities in our weather to changes in the sun.

We have, in truth, a wonderful central sun for our solar system—a vast body 864,000 miles in diameter and at a temperature of nearly 11,000° F. On its surface, or better probably, in its outer layers, there are the sun spots and the white spots or faculæ. The outermost layer is the corona which may extend at times even two or three million miles from the sun. All of these things have been carefully observed, some of them for more than a century. The sun spots are probably the most remarkable. They are distinctly periodic with a period of 11.2 years, as regards number, size, and place of occurrence. This is only an average period, however, as the time interval from maximum to minimum varies from 8 to 17 years. The rise from minimum to maximum is rapid, requiring about 4.6 years, while the fall is slower requiring 6.5 years. The spottedness of the sun is expressed by means of the Wolfer sun-spot numbers which depend upon and are computed from both the number of spots and the number of groups.[3] These numbers are practically zero for a sun-spot minimum and rise to almost 150 for a very prominent maximum. The sun spots are also strongly magnetic, two near-by spots usually having opposite polarity. This periodicity in the activity of the sun is also to be noted in the faculæ, the shape and extent of the corona, and in the energy sent out to the earth by the sun. The corona has well-marked polar tufts and long equatorial streamers at the time of sun-spot minimum. As the spots increase the form becomes more quadrangular and the polar tufts are less marked. At the time of sun-spot maximum the surrounding corona is larger and practically uniform. The energy sent out by the sun and received by the earth also varies with this same period. It is called the solar constant and its average value is 1.946 calories per square centimeter per minute at the outside of the earth's atmosphere. Its periodicity is, however, not well marked, the value at sun-spot maximum being only about 0.03 calories higher than average,[4] or, as Abbot expresses it, a change of 100 in the Wolfer number means a change of 0.07 calories. Thus as a summary it may be said that everything connected with the sun is subject to irregular fluctuation and to a periodic variation with a period between 11 and 12 years.

How can this marvelous sun, through any change in its activity or condition, affect the weather of this earth roughly 93,000,000 miles away with nothing between but empty space, that is, luminiferous ether? First, it can affect the earth through the quantity and quality of the ether waves sent; secondly, by its magnetic field of force; thirdly, by means of its electrostatic field of force; fourthly, by means of charged electrons or penetrating radiation which, originating in radioactive material or atomic disintegration, may make their way to this earth.

The quantity of ether waves sent out by the sun, that is, the sun's insolation, is measured by the solar constant. The average value, as stated above, is 1.946 calories. It is subject to a small periodic variation with the sun-spot period and to much larger irregular fluctuations. How does a change in the solar constant affect our weather? That has been discussed by many investigators, chief among them being Arctowski, Helland-

[3] The periodicity of sun spots was first proved by Schwabe in 1843. The sun-spot numbers were first proposed and prepared by Wolf and later revised and continued by Wolfer. They are computed from the formula $N=(10g+f)$, where g is the number of groups and f the number of spots. The sun-spot numbers are known from about 1749. The values from 1749 to 1901 were published in the MONTHLY WEATHER REVIEW for April, 1902, and from 1902 to 1919 in MONTHLY WEATHER REVIEW for August, 1920, and for 1920, 1921, 1922 in the MONTHLY WEATHER REVIEW for January, 1923. They are now published about every three months in the Journal of Terrestrial Magnetism and Atmospheric Electricity. They are, of course, published and discussed in many other places as well.

[4] Measurements of the solar constant were made as far back as 1837 by Pouillet. Then follows the work of Violle, Crova, Chowlson, Angström and others. In recent times the chief investigators have been Langley, Kimball, and, finally, Abbot and Fowle. The results of their magnificent work are published in the Annals of the Astrophysical Observatory of the Smithsonian Institution. Four large volumes have appeared. Values of the solar constant as determined by Abbot and Fowle exist for certain months in the year from 1905 on. Since June, 1918, continuous determinations have been made. Volume 4 contains the values as far as July, 1920.

Hansen and Nansen, Clayton, Humphreys, and Abbot.[5] It is necessary, in answering the question, to study the weather of the whole world. The correlations are but poorly marked. It would seem that a rise in the value of the solar constant causes a rise of temperature in an equatorial belt and also in a near-polar belt (below 60° north latitude) while in between there is a fall in temperature. This increases the interzonal temperature differences and this very likely results in an increase in storminess, particularly along the margins of these belts. If the solar constant should increase 0.05 calories and stay at the new value it is hardly possible at present to say for any given station just what the difference in weather would be. And that is the simplest case.

As to the quality of ether waves sent us by the sun, it is doubtful if there is any change. The smaller corona at the time of sun-spot minimum might allow more short ether waves to pass. This would favor the building of ozone in the upper atmosphere and a large quantity of ozone would operate to keep the earth warm. It is possible perhaps in this way to explain the slightly higher temperature of the earth during a sun-spot minimum. All this is very far from a proved case, and the experts do not agree.

The sun has a strong and varying magnetic field of force. At the high temperatures existing in the sun it is very doubtful if there can be any permanent magnetism connected with it. It is essentially gaseous and the temperature is too high. The mangetic field of force is more likely caused by the circulation of charged particles, particularly in sun spots. The sun's magnetic field of force, the sun's electrostatic field of force, and the charged electrons and penetrating radiation coming from the sun without doubt affect greatly the earth's magnetism, the earth's atmospheric electricity, and the earth currents. Here the correlations are excellent. It is a grave question if they affect the earth's weather. There are those, Huntington in particular, and others, who have argued for the possibility of a magnetic or electrical control of our weather changes. It seems at present very far from a proved case. One can see of course possible connections. There are charged particles in our own atmosphere. These are in motion in connection with a cyclonic storm and thus such a storm must be weakly magnetic. It would thus be controlled to some extent by the earth's magnetic field of force. There are those who claim that the LOWS follow courses which seem to be more related to the magnetic than to the geographic pole. I would not for a moment belittle those who have made long and laborious investigations along these lines. Their work is necessary and very valuable.

There still remain to be mentioned many investigations showing the relation between our weather and the sun-spot period. This same period exists in our temperatures. The earth as a whole is about 0.5° F. warmer at sun-spot minima than normal. The same period is to be found in the number of storms. For certain belts they are more numerous, in other belts less numerous, at the time of sun-spot maximum. The same period may be found in our barometric pressure, and perhaps rainfall. In all cases the difference is very slight. Among the workers along this line I might mention Arctowski, Köppen, Walker, Helland-Hansen and Nansen, Abbot and Fowle, Humphreys, and Huntington. It is usually stated that these investigations show the relation of our weather to sun spots. This is hardly correct. It is hard to see just what connection sun spots as such have with our weather. If we admit magnetic or electrical control, the sun spots might directly affect the weather. They are rather to be considered simply as an index of solar activity and our weather changes and abnormalities are due to changes in this activity. It should also be mentioned in passing that if a magnetic or electrical control of the weather is ever once admitted, then we are wandering in the maze of lunar and planetary control, for these bodies are all magnets and charged bodies. And there are, of course, those who believe in just this planetary influence. We hear of the eight-year Venus period in connection with our weather, etc., and even the ghost of Vulcan is occasionally called up.

A third cause of abnormalities may be found in unusually high or low temperatures of the surface water of an ocean over a large area. This has been but recently brought to the fore and emphasized as a possible cause of abnormal weather. Science Service News as given in Science for June 6, 1924, contains this. I am quoting only in part:

> Unusually warm water in the northwestern Atlantic Ocean, and especially over the Grand Banks of Newfoundland, is considered by the United States Weather Bureau experts as a very likely cause for one of the wettest month of May in years.

Sir Frederic Stupart gave a paper at the British Association meeting at Toronto in August, 1924, on "The variableness of Canadian winters." An abstract of the paper is contained in the Bulletin of American Meteorological Society for August–September, 1924. I am quoting from this abstract:

> In normal seasons North Pacific cyclonic areas usually move southeastward, with their centers well off the coast until at about the latitude of northern British Columbia they enter the continent while anticyclonic conditions of moderate intensity and low temperature prevail in Yukon and the Mackenzie River.
>
> In certain years, however, the Pacific cyclonic areas are less intense and enter the continent farther south, while the great anticyclonic developments occur in the far north and sweep southeastward over Canada, accompanied by severe cold waves, which not infrequently reach the Atlantic coast. These conditions lead to abnormally cold winters in Canada.
>
> In other years the North Pacific cyclonic areas appear to be of such intensity that they force their way into the continent in high latitudes and actually prevent the formation of anticyclones and their concomitant low temperature. These conditions lead to mild winters in Canada.
>
> The Meteorological Service is investigating as to whether there is any connection between the temperature and position of the Japan current and the behaviour of these cyclonic areas.

It may thus be true that a change from normal of the surface temperature of an ocean over a large area may influence the semipermanent highs and lows (the centers of action, as they are sometimes called) and thus affect the track followed and the characteristics of the moving HIGHS and LOWS so that at any given station a month may be abnormal as regards temperature, precipitation, number of storms, etc.

But why does the surface temperature of the oceans over a large area depart from normal? It may in part be due to heating or cooling on that spot, but more likely it is due to some change in the direction, velocity, quantity of water carried, or temperatures of ocean currents. There are many factors which determine these matters in connection with ocean currents. Chief among them may be mentioned temperature differences between Equator and Pole, rotation of the earth, configuration of the shore line, differences in salinity, inflow of water, direction and velocity of the wind. Some of these factors are constant; others change. The heating of the equatorial waters depends upon the insolation from the sun, In other words,

[5] In the two recent excellent research books, Earth and Sun, by Ellsworth Huntington, and World Weather, by H. H. Clayton, these matters are fully discussed. There are numerous references to the periodical literature. These books are good places to begin if anyone wishes to read up on these subjects.

this would vary with the solar constant. Perhaps we are getting back again to the changes in the solar constant as the *primary* cause of abnormalities in the weather. Changes in the solar constant would thus cause a different amount of heating of the equatorial waters. This would affect the ocean currents, which would in turn determine the temperature of the surface water over a large area. A change here would affect the semipermanent HIGHS and LOWS which would modify the paths followed and the characteristics of the moving HIGHS and LOWS, which would cause the weather at a given station to be abnormal. The chain of events is a long one and a considerable time interval must elapse between primary cause and result. Thus a change in the solar constant might cause a weather abnormality at a given station months or even years later. The two places where changes in the surface temperatures of the ocean are going to cause the greatest abnormalities in North American weather are probably between Iceland and the Grand Banks and south of the Aleutian Islands.

A *fourth* cause of abnormalities may be found in changes in the composition of the atmosphere, particularly in its carbon dioxide (CO_2) and ozone content. The ocean is a great storehouse for carbon dioxide, and any change in its temperature would thus put into the atmosphere or take from it large quantities of CO_2. It has been pointed out, however, that the quantity of CO_2 in the atmosphere is so large (a layer about 10 feet thick) that a change of even 20 per cent in the amount would not change the selective absorption which is due to it. Ozone in the upper atmosphere has already been mentioned. A change in the quality of the ether waves received from the sun would change the quantity of ozone and thus its hothouse effect on the earth. It has, however, never been proved that this ozone exists, and it is extremely doubtful if it is the cause of any temperature changes.

In the *fifth* place many of our abnormalities in weather are said to have accidental causes. This in a sense is a misnomer as there are no accidents in nature. When the causes are many and minute, and when the relation between cause and effect is impossible to trace, we are prone to consider the causes as accidental. The story of how a Kansas grasshopper caused a drought in New England illustrates this in a fanciful way. This obscure cause, the Kansas grasshopper, had pulled down several heads of wheat in a Kansas wheat field. The farmer, viewing the field, noticed in particular this destruction and decided to plow the wheat under rather than to harvest it. This changed the amount of moisture evaporated from the soil to such an extent that the passing LOWS were deflected from their course and brought no rain to New England. But let us pass to a more sensible illustration. It is June. A heavy thundershower brings nearly 2 inches of rain to a certain station and 20 miles away, at another, there is no rain. At the end of the month the rainfall at one station is normal and at the other it is 2 inches above normal. We say this abnormality is accidental. Rather the causes that produced a thundershower at one station and not at another were many, small, and there is no possibility of tracing the connection. Let us take a third illustration. December, 1923, was abnormally warm. It is still fresh in our minds, and it is always better to discuss an abnormality while it is still well remembered. This abnormality was pronounced. The greatest departure was +12°. In Williamstown the departure from normal was 8.9°. This is next to the largest in 40 years. This abnormality was widespread. It covered nearly the whole of the United States. This abnormality was long continued. It existed during November and a part of January.[6]

Such an abnormality as that can hardly result from small, insignificant, *accidental* causes. This can always be claimed when an abnormality is pronounced, widespread, and long continued. If not due to accidental causes, then why was December, 1923, so abnormal in temperature? It was not due to volcanic eruptions, for there had been none, and in any case they cause a decrease, not an increase, in temperature. The sun's activity and condition as evidenced by the solar constant and sun spots should next be considered. Table 9 contains the values of the solar constant and the Wolfer sunspot numbers month by month for the last four years. The solar constant had been but little below normal for July, August, September, October, and November, 1923. During the last half of 1922 and the first half of 1923 it had been markedly below normal. A low value of the solar constant should cause most of the United States to be too warm. The disconcerting thing is that the abnormality of temperature did not continue of the same nature and amount for a much longer period. The year 1923 was the time of the sun-spot minimum. The lowest value for any month was that of 0.5° for August. The year as a whole averaged 5.5°. During a sun-spot minimum the earth as a whole should be about 0.5° F. warmer than normal. The disconcerting thing here is that each month of 1923 did not show the same amount and kind of abnormality, for more than a year was spent in passing through a very flat minimum. According to Kullmer's work, at the time of sun-spot minimum storms should be more common in an irregular middle belt across the United States and less common in belts above it and below it. The disconcerting thing here is that the area of abnormally high temperature covers all of these belts. Possibly some change in ocean surface temperature over a large area caused this abnormality of temperature in December. A change south of the Aleutian Islands would be the most likely cause. Perhaps the small value of the solar constant a year before and continuing for a year or more weakened the Japan Current, so that the Aleutian Islands LOW and thus also the HIGH in northern Canada. were weaker than usual. This would cause fewer cold waves, and thus make the temperature unusually high, We are waiting here for the results of the investigations such as these by Sir Frederic Stupart along this line.

The problem of why December, 1923, was abnormally warm can also be approached from the other side. December was abnormally warm because the moving areas of high pressure entered the United States from the Pacific along the Oregon and California coasts rather than from Alberta. They often dropped far to the south, moved slowly, and were not accompanied by cold waves—those vast outpourings of cold air which come down from Canada and sweep over a large portion of the United States at times. But why did these highs have such unusual characteristics? Probably because the semipermanent HIGH which in winter covers the north-central portion of Canada was weak. And why was it abnormally weak? Here we lose the scent and have penetrated as far as we can at present from this side of the question. But in general terms it amounts to this. Our weather is absolutely controlled by the passing areas of low and high pressure. If a month is abnormal, it is because the direction and velocity of motion and the characteristics of the LOWS and HIGHS were different. Why are they different? Because the meteorological

[6] For details, the temperature charts in the MONTHLY WEATHER REVIEW for November and December, 1923, and January, 1924, should be consulted.

condition of the country is different or there is a difference in the semipermanent HIGHS and LOWS called the centers of action. The last are probably the most important. The outstanding question is why these semipermanent HIGHS and LOWS are different in different years.

These five causes of abnormalities which have been treated are the only ones which are known to have been investigated up to the present time.

In order to facilitate the intensive study of this very important problem of the cause of abnormalities, it is suggested that certain data might be published regularly each month in the MONTHLY WEATHER REVIEW, namely, the values of the solar constant; the values of the Wolfer sun-spot numbers; any definite information about volcanic eruptions, unusual oceanic surface temperatures, changes in the carbon dioxide or ozone content of the atmosphere; a more detailed description of the intensity and position of the semipermanent HIGHS and LOWS.

There is a crying need for a weather map of the whole Northern Hemisphere, if not for the world. Any change in the semipermanent HIGHS and LOWS would then become apparent at once. It is probably impossible at present to secure the observations in time and it is also too expensive. Perhaps the data could be obtained in in time to publish these daily maps in the MONTHLY WEATHER REVIEW for the month in question. A world meteorological foundation has been proposed. It has been stated that to gain the participation of America, some problem having a bearing upon American meteorology should be undertaken. What better problem could be undertaken than to secure sufficient data to make an excellent and complete daily weather map for the whole world and to make possible its speedy publication.

In concluding it may be said that this paper is unsatisfactory because it does not solve the immense problem of the cause of each and every abnormality. That solution seems a little beyond our reach at present. But progress, and distinct progress, has been made. It has been rather the purpose of this paper to point out the importance of the problem and the progress that has been made. It is a pressing problem. There is great eagerness for its solution. It is to be hoped that many meteorologists will lend their best efforts to its solution.

TABLE 1.—*The average monthly and the average yearly temperatures (°F.) 1816 to 1838, in Williamstown, Mass.*[1]

	January	February	March	April	May	June	July	August	September	October	November	December	Year
1816	21.0	25.2	29.3	42.7	[2] 52.8	[3] 60.8	[1] 64.6	64.9	55.0	48.4	39.7	27.7	44.3
1817	20.8	15.1	28.6	43.8	54.3	[1] 59.6	67.4	66.5	58.7	45.1	38.8	27.0	43.8
1818	20.3	[2] 14.9	31.2	[3] 39.1	53.6	68.5	71.3	65.9	55.6	48.1	39.8	22.0	44.2
1819	28.1	27.7	[1] 25.9	42.2	55.3	67.2	70.3	69.0	[3] 64.0	46.3	38.2	25.1	46.6
1820	19.8	29.4	30.7	45.6	54.7	67.4	[3] 75.1	67.6	61.4	45.8	33.0	20.8	45.9
1821	17.5	29.6	30.0	41.2	55.9	68.0	67.8	68.3	61.2	46.1	35.9	24.2	45.5
1822	17.2	23.3	34.4	44.8	59.5	66.3	71.3	67.7	63.1	48.1	39.7	25.5	46.7
1823	22.9	16.9	30.6	47.1	54.9	65.4	71.2	67.7	56.1	44.3	[3] 31.3	28.5	44.7
1824	26.1	24.4	31.4	45.7	55.1	67.5	67.7	[3] 64.3	59.1	44.6	34.5	30.1	45.9
1825	23.1	26.9	36.4	46.1	57.3	70.0	74.9	68.8	58.4	50.8	35.0	28.8	48.0
1826	25.3	26.1	33.2	40.7	[3] 64.9	68.9	71.0	69.6	62.8	50.1	36.9	26.5	48.0
1827	[2] 16.4	25.6	33.2	48.1	57.3	65.4	69.5	66.6	59.9	49.2	[1] 30.4	29.2	45.9
1828	28.2	[3] 33.0	35.2	40.9	58.3	[3] 71.7	69.2	[3] 71.0	60.6	46.1	38.4	32.6	[3] 48.8
1829	20.7	17.0	28.4	43.4	60.1	66.7	68.7	67.3	[1] 53.7	47.9	35.9	[2] 34.5	45.4
1830	20.6	21.0	34.0	[3] 49.4	55.5	64.1	72.4	67.8	57.9	48.9	[2] 43.1	30.7	47.1
1831	17.5	18.7	[2] 37.9	46.8	60.8	71.1	71.4	69.0	59.2	49.9	36.1	[1] 14.0	46.0
1832	23.4	23.8	33.7	41.3	54.2	66.2	68.5	67.9	58.5	48.0	38.0	27.6	45.9
1833	28.3	19.6	30.0	48.5	62.2	61.7	68.2	64.5	59.1	46.7	34.0	26.5	45.8
1834	19.9	32.5	34.6	47.3	57.7	63.2	73.3	67.5	60.2	44.0	33.7	23.0	46.4
1835	20.2	19.9	29.9	42.3	54.8	64.7	68.6	66.1	[3] 54.9	[3] 51.5	36.5	20.2	44.1
1836	22.8	15.7	[3] 26.1	40.4	55.9	62.4	69.8	[1] 61.7	59.0	[3] 40.5	32.8	23.6	[1] 42.6
1837	[1] 13.3	21.6	28.3	40.4	[1] 51.9	63.4	[3] 66.5	64.9	56.5	44.5	35.8	24.6	[3] 42.6
1838	[3] 29.2	[1] 13.1	33.0	[1] 37.9	54.0	68.5	72.2	66.4	59.1	[3] 43.9	31.5	[3] 18.7	43.9
Normal	21.8	22.7	31.6	43.7	56.6	66.0	70.0	67.0	58.9	46.9	36.1	25.7	45.6

[1] Lowest average. [2] Next lowest average. [3] Highest average.

TABLE 2.—*Lowest observed temperatures (°F.) 1816 to 1838, in Williamstown, Mass.*

	June	July	August
1816	[1] 35.0	[1] 43.0	[1] 37.5
1817	[2] 36.0	50.0	44.0
1818	49.6	53.5	45.0
1819	51.0	48.5	43.7
1820	43.3	[2] 57.0	48.0
1821	43.0	48.7	47.0
1822	46.6	50.0	41.0
1823	46.0	52.4	48.0
1824	48.2	52.0	45.0
1825	55.0	56.0	53.3
1826	52.0	56.0	53.0
1827	44.8	52.0	43.0
1828	54.0	57.0	50.5
1829	48.5	51.8	[3] 43.4
1830	49.8	54.5	[4] 49.0
1831	46.0	50.8	40.5
1832	43.5	52.0	42.0
1833	[5] 43.0	51.0	44.0
1834	42.0	[6] 52.0	48.2
1835	49.3	54.0	48.0
1836	47.0	52.0	[2,7] 39.5
1837	46.0	[8] 54.0	[5] 43.0
1838	50.0	52.5	[6] 42.0
Average	46.5	53.2	45.1

[1] Lowest average. [2] Next lowest average. [3] 41 at SR. [4] 46½ at SR. [5] 39 at SR. [6] 46 at SR. [7] 38.5 at SR. [8] 48 at SR.

TABLE 3.—*The average difference between the minimum and the 7 a. m. temperature at Albany, N. Y.*

	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	Normal
June	2.8	4.2	3.8	4.1	3.4	4.8	5.7	4.6	4.9	5.0	1.3
July	2.8	2.7	3.9	3.4	3.7	4.0	3.9	4.1	4.6	5.0	3.4
August	3.5	3.4	3.7	3.6	3.1	2.8	4.1	2.7	3.9	3.6	3.4

TABLE 4.—*The average monthly temperatures (°F.) for 1816, at Williamstown, Mass.*

	January	February	March	April	May	June	July	August	September	October	November	December
¼ (7 a. m.+2 p. m.+9 p. m)	21.0	25.2	29.3	42.7	52.8	60.8	64.6	64.9	55.0	48.4	39.7	27.7
¼ (7 a.m.+2p.m.+9 p.m.+9p.m.)	20.9	24.7	28.7	41.8	51.8	60.2	63.6	64.1	54.0	47.6	39.5	27.4
Difference	0.1	0.5	0.6	0.9	1.0	0.6	1.0	0.8	1.0	0.8	0.2	0.3

TABLE 5.—*The average monthly and the average yearly temperatures (°F.) 1901 to 1923, in Williamstown, Mass.*

	January	February	March	April	May	June	July	August	September	October	November	December	Year
1901	22.0	16.2	30.6	45.8	55.6	66.0	70.2	69.0	60.0	48.8	[1] 31.4	25.2	45.1
1902	21.2	21.6	38.2	46.0	54.7	61.6	66.6	63.8	59.4	49.0	[3] 42.2	22.5	45.6
1903	24.2	27.0	41.6	45.2	58.4	[1] 59.6	67.2	[1] 60.4	59.2	49.7	33.4	21.7	45.6
1904	14.7	16.0	30.0	40.7	59.6	64.8	66.8	62.2	57.3	46.2	32.0	19.2	[1] 42.5
1905	18.0	15.5	30.8	44.4	56.1	62.9	69.6	63.9	58.2	49.0	35.2	29.6	44.4
1906	29.6	22.2	26.3	43.6	55.4	65.0	68.6	68.5	61.2	49.9	36.0	23.8	45.8
1907	22.5	15.2	34.2	[1] 40.1	50.8	62.1	68.7	64.0	60.2	[1] 44.2	37.1	30.8	44.2
1908	24.8	19.1	33.4	43.7	58.2	64.7	70.5	65.1	61.8	50.8	38.5	26.9	46.5
1909	25.1	27.7	30.3	43.8	54.9	64.7	66.8	64.7	58.9	46.5	41.0	23.3	45.6
1910	24.7	21.0	39.0	49.2	55.0	62.2	70.2	65.4	59.6	51.0	34.6	19.9	46.0
1911	26.6	24.1	29.7	42.2	[3] 62.8	62.8	71.9	67.4	58.5	47.7	35.3	32.8	46.8
1912	14.8	18.5	28.2	44.6	57.5	62.2	69.5	64.2	59.4	50.3	39.1	32.5	45.1
1913	[3] 33.8	21.3	37.8	46.9	54.5	64.8	69.0	66.9	57.7	53.4	41.7	29.8	[3] 48.1
1914	21.9	[1] 14.9	31.0	41.5	57.7	63.6	67.5	67.1	57.8	52.7	35.4	24.7	44.7
1915	26.1	[2] 27.8	28.9	49.5	52.2	63.7	68.3	64.8	[3] 63.2	50.3	38.7	26.2	46.6
1916	25.8	19.3	[1] 22.3	43.7	56.0	61.0	71.3	68.9	59.4	49.5	36.8	25.8	45.0
1917	23.2	18.8	31.6	42.7	[1] 47.7	64.3	70.0	[3] 70.1	[1] 55.8	45.8	32.6	[1] 16.5	43.3
1918	[1] 11.5	20.1	32.7	44.1	61.8	61.2	68.7	68.6	56.5	51.4	39.8	30.5	45.6
1919	27.1	26.4	36.2	43.0	56.2	[3] 68.1	68.2	64.8	60.3	50.9	37.2	20.4	46.6
1920	13.4	20.2	32.3	41.1	53.0	62.8	66.8	62.3	61.0	[3] 54.4	35.8	29.2	44.9
1921	25.6	26.4	[3] 42.0	[3] 50.7	57.6	64.4	[3] 72.5	66.4	62.1	49.6	37.5	23.5	47.8
1922	18.6	25.6	33.8	43.6	58.2	67.0	69.2	65.3	60.9	48.4	37.8	26.2	46.3
1923	19.2	16.4	27.3	44.1	53.4	66.0	[1] 66.1	66.5	61.0	48.2	37.9	[3] 34.7	44.9
Normal	22.4	20.9	32.5	44.4	56.0	63.8	68.9	65.8	59.5	49.5	36.8	25.9	45.5

[1] Lowest average. [3] Highest average.

TABLE 6.—*Lowest minimum temperatures (°F.) 1901 to 1923, at Williamstown, Mass.*

	June	July	Aug.
1901	44	48	[3] 56
1902	41	47	44
1903	38	43	42
1904	41	44	[1] 35
1905	38	47	42
1906	38	48	46
1907	38	45	43
1908	37	48	40
1909	43	43	42
1910	37	49	43
1911	45	49	44
1912	[1] 35	[1] 41	[3] 38
1913	[2] 35	44	41
1914	42	47	45
1915	38	48	40
1916	40	47	46
1917	[3] 48	[3] 50	46
1918	37	[2] 42	42
1919	42	48	45
1920	38	44	44
1921	38	[3] 50	44
1922	43	47	45
1923	42	46	[2] 38
Average	39.9	46.3	43.1

[1] Lowest average. [2] Next lowest average. [3] Highest average.

TABLE 7.—*The departure from normal of the various months of 1816 (°F.)*

	January	February	March	April	May	June	July
Cambridge	+5.0	−0.6	−4.1	−2.5	−4.5	−6.0	−6.5
New Bedford	−2.2	+1.6	−1.9	−1.4	−2.5	−5.0	−5.8
New Haven	−4.0	0.0	−4.0	−5.0	−5.0	−7.0	−7.0
Salem	−0.4	+0.3	−4.7	−0.7	−3.0	−5.4	−5.7
Williamstown	−1.5	+4.0	+0.6	+0.7	−1.4	−3.2	−3.8
Do	−0.8	+2.5	−2.3	−1.0	−3.8	−5.2	−5.4

	August	September	October	November	December	Year	Normal based on—
Cambridge	−3.2	−4.8	−0.1	+3.5	−2.3	−2.2	----------
New Bedford	−2.2	−3.3	+0.8	+2.6	+2.0	−1.4	1813–1856
New Haven	−2.0	−5.0	−1.0	+2.0	0.0	−3.0	1778–1920
Salem	−1.6	+0.5	−1.6	+1.7	+1.8	−1.5	1786–1828
Williamstown	−2.0	−3.4	+1.4	+0.6	+2.3	−0.5	1816–1819
Do	−2.1	−3.9	+1.5	+3.6	+2.0	−1.3	1816–1838

TABLE 8.—*The departure from normal of the months of various years at Williamstown, Mass., °F.*

	January	February	March	April	May	June	July	August	September	October	November	December	Year
1816	−0.8	+2.5	−2.3	−1.0	−3.8	−5.2	−5.4	−2.1	−3.9	+1.5	+3.6	+2.0	−1.3
1817	−1.0	−7.6	−3.0	+0.1	−2.3	−6.4	−2.6	−0.5	−0.2	−1.8	+2.7	+1.3	−1.8
1835	−1.6	−2.8	−1.7	−1.4	−1.8	−1.3	−1.4	−0.9	−4.0	+4.6	+0.4	−5.5	−1.5
1836	+1.0	−7.0	−5.5	−3.3	−0.7	−3.6	−0.2	−5.3	+0.1	−6.4	−3.3	−2.1	−3.0
1837	−8.5	−1.1	−3.3	−3.3	−4.7	−2.6	−3.5	−2.1	−2.4	−2.4	−0.3	−1.1	−3.0
1838	+7.4	−9.6	+1.4	−5.8	−2.6	+2.5	+2.2	−0.6	+0.2	−3.0	−4.6	−7.0	−1.6
1912	−7.6	−2.4	−4.3	+0.2	+1.5	−1.6	+0.6	−1.6	−0.1	+0.8	+2.3	+6.6	−0.4
1913	+11.4	+0.4	+5.3	+2.5	−1.5	+1.0	+0.1	+1.1	−1.8	+3.9	+4.9	+3.9	+2.6

TABLE 9.—*Solar constant values and Wolfer, 1920–1924*

	January	February	March	April	May	June	July	August	September	October	November	December	Year
1920	1.964	1.956	1.946	1.952	1.953	1.939	1.945	1.930	1.942	1.943	1.949	1.955	1.948
1921	1.958	1.951	1.946	1.947	1.949	1.934	1.945	1.936	1.944	1.947	1.954	1.951	1.947
1922	1.945	1.946	1.934	1.927	1.927	1.917	1.911	1.917	1.903	1.918	1.919	1.927	1.924
1923	1.926	1.915	1.913	1.913	1.915	1.916	1.926	1.931	1.933	1.930	1.931	1.923	1.923
1924	1.930	1.919	1.916	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

WOLFER SUN-SPOT NUMBERS, 1920–1924

1920	57.3	50.9	71.9	14.3	33.7	38.8	26.5	18.6	38.7	48.8	24.6	39.9	38.7
1921	28.8	27.6	27.5	30.5	22.3	34.5	42.4	20.8	16.7	16.1	13.4	15.7	24.7
1922	10.2	27.9	60.0	11.4	7.7	5.8	9.7	5.3	5.2	8.1	6.7	18.7	14.7
1923	5.3	1.6	4.0	5.4	3.2	9.0	3.7	0.5	13.7	11.5	7.3	1.1	5.5
1924	0.7	5.7	2.2	11.5	20.7	24.8	-----	-----	-----	-----	-----	-----	-----

A NEW CLASSIFICATION OF TYPHOONS OF THE FAR EAST [1]

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INTRODUCTION

Cyclonic storms have often played a part in the history of nations. The wreck of the Spanish Armada in 1588 is probably the best-known illustration. In the east, there is a singular parallel in the complete demolition of the Mongolian fleet by a typhoon in the early summer of 1281, during Kublai Khan's invasion of Japan. The immediate cause of this expedition was the execution of Kublai's ambassador by the Japanese emperor in the spring of 1280. The next year, Kublai sent an army of 100,000 men, who embarked in 3,500 ships, to undertake the subjugation of Japan. On July 17, 1281,[2] just at the beginning of the typhoon season, a violent tropical storm came up which sank most of the ships of the grand fleet, then anchored off the coast of Kiushiu Island. Of the 100,000 men on board the ships, only 3 returned to China alive.

In most recent times, all the far Eastern countries have paid heavy tolls to these terrible scourges. During the Cantabria cyclone of September, 1905, hundreds of thousands of dollars' worth of property was destroyed in southern Luzon and in the Visayas, and more than 140 people were killed. In the typhoon of September 7–12, 1904, 4,000 persons were killed in Hué, the capital of Annam. A storm wave caused by the Shanghai cyclone of 1905 overwhelmed the island of Tsun-Ming off the coast of Shanghai, and several thousand persons were drowned. A great flood accompanying the typhoon of August 7–11, 1910, killed more than 1,200 people in Japan. More recently, the Swatow typhoon of August 2, 1922, brought calamities to the region around Swatow; more than 5,000 people were killed or drowned in Swatow alone.

Before considering the characteristics and habits of typhoons, it is necessary to define what is meant by "typhoon." Algué has described a typhoon as a vast whirl of aerial currents which surround a central calm space of relatively small dimensions called the "vortex," or center of the storm. The central region of calm, relative or absolute, is, however, only found in the better-developed tropical cyclones. In the reports of the Zikawei Observatory, practically all the tropical storms are called typhoons. Because of the diversity in the use of the word, a clear distinction between a typhoon and a mere depression, based upon the intensity of the storm, has to be made.

The barometric readings do not indicate the intensity of a cylcone, for this intensity depends upon the rate of

[1] Acknowledgments.—With a few alterations this paper was written in 1918 to fulfill part of the requirement for the degree of Ph. D. in Harvard University, Cambridge, Mass. Since then, quite a few papers have been written on the subject of the typhoons of the Far East, the most notable being Father Louis Froc's Atlas of the Tracks of 620 Typhoons 1893–1918, published by Zikawei observatory, Shanghai. In view of the new light thrown upon the subject by the recent papers, additional footnotes have been inserted wherever occasion demands. The subject of this thesis was chosen mainly because of the economic importance of typhoons in the Far East. The writer has also an added interest because of the fact that he is a native of a region on the coast of China which is visited by those storms. The material used in this report has largely been obtained from the annual and monthly meteorological reports of the Zikawei Observatory (Bulletin des Observations), the Journal of the Meteorological Society of Japan, the annual reports of the Central Meteorological Observatory of Japan, and especially from the monthly bulletin of the Philippines Weather Bureau; without these publications this investigation would not have been possible. It has been the privilege of the writer to carry out his work under the supervision of Prof. Robert DeCourcy Ward, to whose advice, encouragement, and helpful suggestions the writer takes this opportunity to express his sincere thanks.

[2] The Chinese date for this memorable event is the first day of the seventh month in the eighteenth year of Chi-Yuen, Juen dynasty. In western chronology, this is July 17, 1281 (according to Rev. P. Hoang's Concordance des Chronologies neomeniques, Chinoise et Européenne, Shanghai, 1910, p. 269.) In this connection, attention may be called to an interesting book written by a Japanese author, N. Yamada, The Mongol Invasion of Japan, published in London in 1916.

the decrease of pressure, and not on the absolute minimum pressure. Owing, however, to the scarcity of data as to the pressure gradient, a classification of typhoons according to gradients is not practical. On the other hand, the data concerning wind velocity are abundant, and the wind velocity furnishes a good criterion of the violence of a storm. For these reasons, the present writer has used the recorded wind velocities as the basis of his grouping of typhoons and of ordinary depressions.

The tropical storms of the Far East have been divided into three classes: (1) Typhoons of the first order, or class A, in which a wind velocity of Beaufort scale 12 was registered. Practically all typhoons of a destructive nature are accompanied by winds of hurricane force. (2) Typhoons of the second order, or class B, in which a wind velocity of Beaufort scale 6 was registered. (3) Depressions which are feebly developed, have ill-defined centers, and may be called tropical storms.

Any such scheme of classification is necessarily arbitrary, for no clean-cut lines can be drawn between typhoons and mere depressions. Besides, the wind velocities are usually estimated by the observers, and hence the personal error is unavoidable. Owing to the fact, however, that storms have been called typhoons in one report, and depressions in another, it is necessary to have some standard in order to settle such cases. Under the circumstances, wind velocity seems to be the only feasible basis that can be used in distinguishing tropical storms of varying intensity.

There is another class of storms often called typhoons which needs a word of comment. This group includes storms which originate between latitude 20°–25° N. and longitude 120°–130° E., passing over Loochoo Island, and thence move to Japan or to the Pacific. These occur mostly in winter and spring, and originate in too high a latitude for typical tropical storms. Their course is always eastward, and lacks the first branch of the usual parabolic curve, which is an earmark of a tropical cyclone. In the following Table 1 the storms of this group which occurred in the years 1904–1915 have been enumerated by months and their seasonal distribution is compared with those of typhoons and of continental depressions. The similarity with the latter class is quite obvious.

TABLE 1.—*Seasonal distribution of typhoons and of continental depressions*

	January	February	March.	April	May	June	July	August	September	October	November	December	Total
Typhoons	3	1	6	4	11	13	39	51	46	36	22	15	247
Continental depressions	38	32	45	60	56	48	20	8	14	27	31	33	412
Storms originating near Loochoo	7	8	5	5	7	4	0	0	1	5	2	2	46

Typhoon tracks are usually parabolic in shape. They vary, however, both in form and in geographical location. Such variations are not haphazard, but are according to certain more or less definite rules. Before any inquiry into these rules can be undertaken, it is necessary to subdivide typhoon tracks into different classes.

This classification has the merit of being simple, and in a scheme of this sort, simplicity is always of prime importance. As our practical interest in typhoons concerns mainly the damage done in the region which is affected by the violent wind, or by the cyclonic wave which accompanies the storm, this classification has the additional advantage of being comprehensive. Each type of typhoon has its own sphere of influence. The devastation, caused by a certain class of storm will, if we except the damage done to steamers at sea, be limited to the region whose name that class of storm bears.

HISTORICAL REVIEW OF TYPHOON CLASSIFICATIONS

Father F. S. Chevalier, S. J., in his pamphlet, The Typhoons of the Year 1893, classified typhoons according to the countries which they visit, and divided them into three groups, viz, typhoons of China, typhoons of Japan, and typhoons of Cochin China. He deemed it unnecessary to make the typhoons of the Philippines a separate group, as they were either typhoons of China or of Cochin China. The typhoons of Japan were subdivided into (1) those which originated east of the Philippines and recurved near the south of Formosa, and (2) those which originated further to the east, and recurved before reaching either the Philippines or Formosa. The typhoons of the first division come early or late in the season, in the months of May, June, or October, while the typhoons of the second division occur in the midseason. Among the typhoons of Cochin China, Father Chevalier[3] distinguished the typhoons of the Gulf of Tonking and the typhoons of Annam. The latter type occurs in the months of November and December, while the former type comes in the same season as the Japanese typhoons which recurve in the neighborhood of Formosa. Father Chevalier subdivided the typhoons of China into (1) those which move onto the land southwest of Hongkong, (2) those which reach land between Hongkong and Foochow, and (3) those which pass inland near the mouth of the Yangtze River. Of the typhoons of this last type, Father Chevalier said that they do not appear before the middle of July, or after the middle of September.

The Chevalier classification is, however, not without its defects, for it is incomplete. Father José Algué, S. J., has pointed out in The Cyclones of the Far East[4] that the conclusion that the typhoons of the Philippines must belong either to the Chinese or Cochin China group is erroneous. This argument is based upon two concrete examples. As will be seen later, such storms as those referred to by Father Algué are not rare, especially in the months of October, November, and December. Besides the typhoons of the Philippines there is another group of storms which Father Chevalier has failed to place in a separate class, viz, those of the Pacific. These storms often recurve before reaching longitude 130° E., and thence travel along the second branch of their parabolic path far to the south of Japan. These should, therefore, not be classified as the typhoons of Japan.

Dr. W. Doberck, formerly director of the Hongkong Observatory, in his The Law of Storms in the Eastern Seas[5] suggested the grouping of typhoons into four classes according to the path which they usually follow. He did not explicitly name each of his classes, but from his description of these different types, they may be roughly summed up as (1) typhoons of the Gulf of Tonking, (2) typhoons of China, (3) typhoons of Japan and the Pacific Ocean, and (4) typhoons of the Philippines, south of Luzon. No subdivisions of any of these classes were suggested. Later, in 1898, Dr. Doberck revised his classification, basing the revision on 244 typhoons observed during the 13 years 1886–1898.

[3] F. S. Chevalier, S. J., 2d annual report to the Shanghai Meteorological Society for the year 1893, chap. 4, p. 89. Shanghai, 1894.
[4] José Algué, S. J. Cyclones of the Far East, p. 89. Manila, 1904.
[5] W. Doberck, The Law of Storms in the Eastern Seas, Shanghai, 1887, p. 31. Chinese Imperial Maritime Customs, Special Series 1167.

TABLE 2.—*Doberck's classification of typhoons*

Type	Origin	Path, general description	Season	Per cent
1a	China Sea north of lat. 15° N.	Enter continent west of Hongkong.	June-Sept	10
1a′	Pacific	Enter China Sea and continent west of Hongkong.	July-Oct	12
1b	do	Enter China Sea north of lat. 15° N. and disappear to the southwest.	Late in the year	2
1c	China Sea	Enter continent east of Hongkong.	June-Sept	4
1d	do	Recurve and sometimes move into the Pacific.	May-Sept	2
2a	Pacific	Enter China Sea and China east of Hongkong.	July-Sept	2
2b	do	Enter Formosa and hence south China.	June-Sept	7
2c	do	Enter China north of Formosa	June-Sept	3
2d	Pacific, high latitude.	Enter China	July-Aug	4
3a	Pacific	Enter Luzon and recurve	Oct.-Nov	1½
3b	do	Enter Formosa and recurve to Japan.	October	1
3c	do	Enter Korea	July-Sept	4
3d	do	Recurve and enter Japan	Aug.-Sept	15
3e	do	Remain in the Pacific	May-Dec	12½
4a	China Sea south of lat. 15° N.	Enter Hainan and Annam	May-Dec.; seldom in Aug.	8½
4a′	Pacific	Enter China Sea south of lat. 15° N. and hence go to Annam.	Beginning and end of typhoon season.	3
4b	do	Enter China Sea south of lat. 15° N., move to southwest and disappear.	Sept.-Dec	4½
4c	do	Recurve in the China Sea and reenter the Pacific.	Beginning and end of typhoon season.	4
4d	(?)	Gulf of Siam	April and Dec	1

The four original groups were retained, but each group was subdivided into four or five types, making 19 types in all. (See Table 2.) Group 1 comprises all the typhoons that enter the China Sea north of latitude 15° N. Group 2 includes all the typhoons of China originating in the Pacific. Group 3 includes all the typhoons of Korea, Japan, and the Pacific, and also some of the Philippines. The storms of this group are similar to those of group 1 except that they enter the China Sea south of latitude 15° N. Each group is represented by an Arabic numeral, while the subdivisions are denoted by letters.

Doberck's classification has the advantage of being very definite. The origin of each class of typhoon is roughly indicated, and each class is very narrowly and distinctly limited. Thus, if typhoons are classified according to Father Chevalier's method many cases are on the border line between two or more types, and hence may be classified under more than one heading. Such cases are rare if Doberck's scheme is used.

The clear distinction possible in Doberck's classification is, however, gained at the expense of simplicity. Unless one has a thorough knowledge of the classification, it is not easy to remember just what a particular combination of numerals and letters stands for. Neither numerals nor letters have any very sharply defined meanings. Furthermore, the subdivisions of the groups are not always homogeneous, and they are often inconsistent. Take, for instance, the typhoons of group 3. Those of types 3b, 3c, 3d, and 3e all have immediate or remote effects upon Japan, but those of type 3a belong to a much lower latitude, and have nothing in common with the storms of the other types in the same group, save that all of them recurve before reaching longitude 120° E. The different types in groups 1 and 4 are not homogeneous. Doctor Doberck seems to have devised his classification, not from a general point of view, but with local forecasting in mind.

In Father Algué's book, The Cyclones of the Far East,[6] two classifications are outlined. It is to the second classification, a classification of cyclones by zones of formation and course of trajectory, that attention is here directed. It is the latter scheme which is actually employed by the author. There are eleven types, under three headings: (1) Typhoons formed in the Pacific; (2) typhoons formed in the China Sea; and (3) typhoons formed in the Sea of Sulu. There are nine types in the first group, while there is only one type in the second and one in the third group.

In the first group, the cyclones which form in the Pacific, Algué has made use of the longitude and latitude of Manila as the dividing lines between the different subclasses. This method is a perfectly feasible one in the case of the typhoons of the Philippine Islands. But when its use is extended to the typhoons of Japan, it at once loses its significance and causes confusion. Thus, in type 3, under the heading of "cyclones formed in the Pacific which recurved toward Japan near the meridian of Manila," we have typhoons that mainly affect Korea, China, and the Philippines.[7] Many of these can not have the slightest influence on Japan.

As a whole, therefore, while the Algué classification may be excellent for forecasting purposes in the Philippines, it lacks the simplicity which would make it suitable for general use.

THE NEW CLASSIFICATION

It is apparent that there is need of a new classification which shall be both simple and definite. The following plan seems to satisfy the above requirements and to have distinct advantages over the older classifications. We have divided the typhoons into six main groups, namely, (1) typhoons of China, (2) typhoons of Japan, (3) typhoons of Indo-China, (4) typhoons of the Philippine Islands, (5) typhoons of the Pacific, (6) typhoons of the China Sea.[8]

Each group, with the exception of the last, is subdivided into four types, a, b, c, and d. Storms of group 6 include the typhoons of the China Sea originating either in the Pacific or in the China Sea, and filling up in the China Sea without in the meantime reaching the continent, or crossing the Philippine Islands. Storms of this kind occur very rarely, and hence any subdivision is unnecessary. The new classification is as follows:

I. Typhoons of China:
  - 1a. Typhoons of Central and of North China, originating in the Pacific, and passing inland on the Chinese coast north of Wenchow or latitude 28° N.
  - 1b. Typhoons of South China, originating in the Pacific, passing inland on the Chinese coast south of Wenchow, or latitude 28° N.
  - 1c. Typhoons of South China, originating in the Pacific, crossing the Philippine Islands before reaching China.
  - 1d. Typhoons of South China, originating in the China Sea.

II. Typhoons of Japan:
  - 2a. Typhoons of Japan, originating in the Pacific.
  - 2b. Typhoons of Korea, originating in the Pacific.
  - 2c. Typhoons of Japan originating in the Pacific and crossing the Philippine Islands before reaching Japan.
  - 2d. Typhoons of Japan originating in the China Sea.

III. Typhoons of Indo-China:
  - 3a. Typhoons of Indo-China originating in the Pacific and passing through the Bashi or the Balintang Channel before reaching their destination.

[6] Loc. cit. 1904, pp. 89-93.

[7] Loc cit., plate 19.

[8] "China Sea" is an unfortunate term, as the name of a nation is seldom used as an adjective to qualify another noun. Furthermore, the term is ambiguous when its plural "China Seas" is used to designate the bodies of water that are adjacent to China, i.e., the South Sea, the Eastern Sea, and the Yellow Sea. The translator of Bergholz's article on typhoons in the MONTHLY WEATHER REVIEW of September, 1899, 27: 40, has employed the term "China Sea" in its plural sense. This is a misnomer. The term "China Sea" has, however, been so frequently used and so generally recognized to mean that part of the Pacific Ocean which is included between China, Indo-China, Formosa, Borneo, and the Philippine Islands, that an alteration in the nomenclature does not seem advisable.

III. Typhoons of Indo-China—Continued.
- 3h. Typhoons of the Gulf of Tonking, originating in the Pacific, and crossing the Philippine Islands before reaching the Gulf of Tonking.
- 3c. Typhoons of Annam, originating in the Pacific and crossing the Philippines before reaching Annam.
- 3d. Typhoons of Indo-China, originating in the China Sea.

IV. Typhoons of the Philippines:
- 4a. Typhoons of Luzon, originating in the Pacific, crossing Luzon, and filling up in the China Sea without recurving to enter the Pacific.
- 4b. Typhoons of the Visayas and Mindanao, originating in the Pacific, crossing either Visayas, or Mindanao, or both, and filling up in the China Sea without recurving to enter the Pacific.
- 4c. Typhoons of the Philippines, originating in the Pacific, crossing the Philippine Islands, recurving, and either recrossing the islands, or passing into the Pacific through the Balintang Channel or the Formosa Channel.
- 4d. Typhoons of the Philippines, originating in the China Sea.

V. Typhoons of the Pacific:
- 5a. Typhoons of the Pacific, recurving east of longitude 130° E.
- 5b. Typhoons of the Pacific, recurving west of longitude 130° E., passing over the Loochoo Islands without, however, touching the continent, the Philippines, or the Japanese Islands.
- 5c. Typhoons of the Pacific, limited to the region south of latitude 20° N., and passing near the Philippines.
- 5d. Typhoons of the Pacific originating in the China Sea.

VI. Typhoons of the China Sea:
- 6a. Typhoons of the China Sea, originating in the Pacific or in the China Sea, and filling up in the China Sea without in the meantime passing over the Philippines.

The above plan in the main follows Father Chevalier's classification, but greatly amplifies it. Three new groups, besides the original three (i. e., the typhoons of China, Japan, and Indo-China) have been added, and each group with the exception of the last has been subdivided into four types. The new classification also has some similarities to that of Doberck. Thus Doberck's group 2 corresponds roughly to group 1 of the present scheme, comprising most of the typhoons of China. Doberck's group 3 includes all the typhoons of Japan and the Pacific, and hence embraces groups 2 and 5 of the present scheme. Groups 1 and 4 of the Doberck classification do not correspond to any division of the new scheme.

Father Algué has adopted a method which is just the reverse of that used in the present scheme, for he uses the name of the place of origin as the main heading, and subdivides each group according to the path of the storm. In the present classification, the name of the place of destination is made the main heading, and each group is subdivided according to the origin of the storm.

There are a few points in the new classification to which attention should be directed. In the first place, each numeral and letter is given a definite meaning. The definition of the numerals is quite obvious. The letters "a" and "b" designate those typhoons of the group which have their origin in the Pacific. The letter "c" means those which originate in the Pacific and subsequently cross or pass near the Philippines before reaching their destination or filling up in the Pacific. The letter "d" designates those typhoons which originate in the China Sea. This scheme of subdivision is deemed necessary in order to make the classification clearer and more practical.

In the second place, the use of names has been so restricted that all the typhoons in, for instance, group 1, actually pass inland over the Chinese coast and do not merely approach or pass near it. It is true that storms often influence the weather elements of a place without actually passing over that place. If, however, the geographical description of each of the new groups were considered to include all such cases, much confusion would result. This is more or less the case with Father Chevalier's classification.

Lastly, the present classification rests upon broad general considerations, and does not concern itself with the immediate problem of forecasting the typhoons of any particular region, as is the case with the classifications of Father Algué and of Doberck.

THE DISTRIBUTION AND CHARACTERISTICS OF EACH TYPE OF TYPHOON

One test of the flexibility of any classification of typhoons is the facility with which the different types of storms can be reclassified from different standpoints. The present classification is based upon the origin and the tracks of the storms. It will be seen that the storms of each group occur only within certain months, and that the different types differ in their seasonal distribution.

The following tables include 247 typhoons, observed during the period 1904–1915. From Table 3 it is seen that the storms of groups 1 and 2 occurred chiefly in the months July to September, inclusive. Among the 54 typhoons of group 1, only 1 occurred as late as the beginning of November, and 4 each came in the months of June and October. The remainder, 45 in all, i. e., approximate 84 per cent of the total, occurred in the months of July, August, and September. The seasonal distribution of the storms of group 2 is almost identical with that of group 1; 75 per cent of the total came in the months of July, August, and September; 5 per cent in May, and 10 per cent each in June and October. The maximum number of storms occurred in August, when 23 were registered. This embraces about two-fifths of all the storms in the group.

The typhoons of group 3 occurred later in the season. More than half of them appeared in the months of September and October, while July and November had six each, and August, four. Under the heading "Typhoons that cross the Philippine Islands," all the storms of group 4 are included, besides those of types 1c, 2c, and 3c. These storms occurred in every month of the year except February. The maximum number was recorded in the months of October and November.[9] Besides the minimum in February, there is a secondary minumum in August, the reason for which will be explained later. Typhoons of group 5 occurred in every month, the maximum being in October.

TABLE 3.—*Seasonal distribution of different group of typhoons*

Typhoons	January	February	March	April	May	June	July	August	September	October	November	December	Total
Of China					0	4	17	13	15	4	1		54
Of Japan					3	6	9	23	11	6			58
Of Indo-China				1		1	6	4	12	11	6	1	42
Of the Philippines	1		1	2	3		2	1		3	5	6	24
Of the Pacific Ocean	2(?)	1	5	1	5	2	5	10	7	12	9	8	67
Of the China Sea									1		1		2
Originating in the China Sea	1(?)				3	3	6	5	5	1		1(?)	25
Which crossed Luzon				2	3	3	8	2	11	10	5	2	46
That crossed Mindanao or Visayas	1	0	1	2	1	1	1	2	2	4	9	5	29
Which crossed the Philippines	1	0	1	3	3	3	9	4	12	13	13	7	69

[9] Compare with table given in J. Coronas The Climate and Weather of the Philippines, 1903–1918, pp. 181–185.

TABLE 4.—*Seasonal distribution of different types of typhoons*

Type	January	February	March	April	May	June	July	August	September	October	November	December	Total
1a							2	1					3
1b						2	9	8	9				28
1c						2	4	1	4	4	1		16
1d							2	3	2				7
2a					3	5	5	17	9	6			45
2b							3	5	1				9
2c									1				1
2d						1	1	1					3
3a									3	3			6
3b						1	3	2	5	2	1		14
3c				1					2	5	5	1	14
3d							3	2	2	1			8
4a				1	1		1	1		1		1	6
4b	1		1				1			1	3	3	10
4c				1	2					1	2	2	8
4d													0
5a			4	1	1		2	6	6	10	8	4	42
5b	1?	1?					2	4	1	1	1		11
5c			1		1		1			1		3	7
5d	1?				3	2						1?	7
6a									1	1			2
Total	3	1	6	4	11	13	39	51	46	37	21	15	247
Per cent	1.2	0.4	2.4	1.6	4.4	5.2	15.8	20.6	18.6	14.9	8.4	6.0	

All the storms originating in the China Sea have also been grouped together. These are found to have a seasonal distribution similar to that of groups 1 and 2, that is, they occurred mostly in the months July, August, and September. There was one storm in each of the months of January and December. The fact that they originated in so high a latitude,[10] and so late in the season, makes it doubtful whether they were really tropical storms. It is also interesting to note that of 247 storms, only 25, or 10 per cent, originated in the China Sea.

If we examine each group more closely it will be found that the types in the same group differ in their seasonal distribution. Thus, in group 1, storms of types 1b and 1c both have their destination in South China. No typhoons in type 1b occurred later than the end of September, while among the storms of type 1c four occurred in October, and one in November, showing that all the storms which traveled to South China late in the season had first passed the Philippine Islands. Storms of type 1a, or typhoons of Central China, and those of type 2b, or typhoons of Korea, practically all occurred in the months of July and August. Typhoons of type 2a, however, had a longer season, extending from May to October. There is only one storm of type 2c, and that occurred in the month of September, although, according to Father Algué's charts,[11] typhoons of this type came mostly in the months of May and June. When we come to the discussion of the composite tracks of the months of May and June for the typhoons of 1904–1915, it will be seen that the most frequent tracks there shown are similar to that of the typhoons of this type.

In group 3, it should be noted that the storms of type 3a occurred only in the months of September and October. They would probably have gone inland in South China were it not for the fact that the anticyclone in Siberia had already begun to increase in intensity, and forced these storms westward or even southwestward into the China Sea.

This effect of the Siberian high-pressure area was observed by Doberck in 1898. He stated in his Law of Storms in the Eastern Sea (p. 14), that as long as the southwest monsoon is strong, the typhoons move in some northerly direction. It is only late in the year when the northeast monsoon happens to blow very fresh that typhoons move southwestward in the China Sea.

There is good reason to believe that Doberck's view is correct. An inspection of the Pilot Charts of the North Pacific, published by the United States Hydrographic Office, will show that while in the month of August southwest and northeast winds are equally prevalent in the region of the Formosa Channel, each having 18 per cent of the total frequency, in the months of September and October the northeast wind predominates, with 63 per cent in the latter and 40 per cent in the former month. Following Doberck's view, it is this prevalence of the northeast wind that prevents many of the typhoons of the Pacific from reaching the Chinese coast and causes them to go to Indo-China in the months of September and October.

The storms of type 3c which cross the Philippine Islands and reach Annam naturally come later in the season than those of 3b, which cross the Philippines and reach the Gulf of Tonking, as shown in Table 4. For, as the season advances, the growing anticyclones in Siberia displace the typhoon tracks further to the south. The maximum of the storms of type 3b occurred in September, while the storms of type 3c were most numerous in the months of October and November.

The storms of type 4a and 4b can not be discussed separately from those storms which cross the Philippines and subsequently go to the continent or to the Japanese Islands. For all these storms affect the Philippines just as much as do those of types 4a and 4b. Typhoons cross Luzon in any month from April to December, although the number of storms in the months of April, May, June, and December was small. According to the Bulletin of the Philippine Weather Bureau for December, 1915, only five typhoons have been observed to pass over Luzon in that month during the 35 years ending with December of the year 1915. It is also to be noted that during the height of the typhoon season, i. e., in the month of August, there was a decided minimum (see Table 3).

Typhoons that passed over Mindanao and Visayas were well distributed through the year, but most of them came late in the season, from October to December, with a maximum in the month of November. One case particularly worthy of mention is the typhoon of January 8–12, 1907. This was a violent typhoon of the first order, and entered Mindanao north of latitude 10° N. According to the Manila report, such a case is of rare occurrence.

Storms of type 4c cross the Philippines, recurve in the China Sea, and either fill up in the China Sea or recross the Philippines and fill up in the Pacific. These come at the beginning or end of the typhoon season, in the months of May, June, November, and December. On account of the high pressure on the continent, they are obliged to recurve toward the northeast. Storms of this type crossed Luzon more frequently than they did Visayas or Mindanao; indeed, only two of the eight storms of this type went over Mindanao or Visayas. One case was observed in the month of May, 1913, when a storm coming from the Pacific passed over Visayas, recurved in the China Sea, and crossed Luzon to reenter the Pacific. According to the Bulletin of the Philippine Weather Bureau,[12] six cases of such storms have been observed in the month of May since 1890, although they seldom occurred in other months. A more remarkable case is the typhoon of December 5–10, 1911. This storm struck

[10] Storms seldom originated below latitude 15° N. in the China Sea.
[11] Algué: Loc. cit., plates 21 and 26.

[12] May, 1913, pp. 116–118.

northern Luzon and, immediately after it had passed over the island, recurved toward the Pacific, touching the extreme northern end of the same island, and taking an almost due eastward course. The anticyclone on the continent seems to have been influential in forcing the typhoon to pursue such a course.

Not a single case of a typhoon of type 4d has been observed. There was, however, at least one depression which was reported by the Manila Observatory to have originated in the China Sea, entered the Visayas and southern Luzon, recurved, and reentered the China Sea. This storm occurred in November 13–17, 1908. The storm track was so extraordinary that the Manila Observatory published eight weather maps in the Monthly Bulletin to show the successive positions of this typhoon.

The typhoons of types 5a and 5b occurred mainly in the months July to November, inclusive. They are similar to the typhoons of Japan and China, but recurved farther to the east, and in a lower latitude. Storms of the Pacific limited to low latitudes, or typhoons of the Marianas and Pelew Islands, occurred at the beginning or end of the season. It is sometimes a difficult problem to tell whether the storms of type 5d are tropical or extratropical storms, and it is likely that the two storms of this type recorded in the months of January and December are not typhoons at all. They have been retained in the table for the reason that the latitude of their origin, 18°–19° N. is too low for extratropical cyclones.

Storms of type 6a are very rare. Those which originate in the northern part of the China Sea usually move inland in South China or Indo-China or go to the Pacific, while those which originated in the Sulu (Jolo) Sea almost always passed over the Phillippines. Only two storms of type 6a were recorded during the period 1904–1915. Both occurred in the year 1904, the first in the month of September and the second in October. The place of the origin of the first storm was unknown, but it developed in the northern part of the China Sea. The second storm came from the Pacific, and passed south of Mindanao in so low a latitude that its influence was not felt above latitude 10° N.[13]. Later, the vortex was observed to pass between the island of Jolo (latitude 6° 3′ N.) and the Equator, probably not far from latitude 5° N., and thence emerged on the China Sea, probably to the north of Borneo. Besides these two storms there were several depressions of this type observed in the China and Sulu Seas.

It is believed that the above 21 types include any kind of typhoon that may occur. A possible exception is the type of storm that originates in the Pacific or in the China Sea, traverses the Gulf of Siam, and finds its way into the Bay of Bengal. Father Algué mentioned two such cases in The Cyclones of the Far East.[14] The present article, however, deals with typhoons only, and does not touch upon the cyclones of the Bay of Bengal. If such cases as those mentioned by Father Algué should arise they will be classified according to the path they take before entering the Bay of Bengal.

During the 12 years 1904–1915, only one storm, that of October 19–26, 1905, went as far as the Gulf of Siam.[15] Even this was a doubtful case, as the observations made on board the steamship *Pera* merely suggest that the typhoon might have reached the Gulf of Siam, making its way toward the Bay of Bengal. The first portion of the storm track resembles very much that of the Chittagong cyclone, October 15–25, 1897.[16]

[13] Loc. cit., Oct. 1914, pp. 324-325.
[14] Algué: Loc. cit., pp. 219–229.
[15] Monthly Bulletin of the Philippine Weather Bureau, Oct., 1905, pp. 478–479.
[16] Algué: Loc. cit., plate 54.

THE SEASONAL VARIATIONS OF TYPHOON TRACKS

Like the tropical cyclones of other regions, typhoons occur mostly in the late summer and early autumn. The average number of typhoons in a year, however, far exceeds the number of tropical cyclones observed in one season in other regions. According to von Hann[17] the average annual number of cyclones in the region of the West Indies is 5; in the Bay of Bengal, 2; in the South Pacific, 4; in the South Ocean, 9; and in the Far East region, from 19 to 21. Hence, the number of typhoons in each year is more than double the number of tropical cyclones in any other region. There is at least a reasonable basis for the belief that this difference is merely apparent and not real. The question obviously depends upon what is taken as constituting a *cyclone*, a *typhoon*, or a *hurricane*. As mentioned in the introduction, any line drawn between well-developed cyclones and mere depressions must necessarily be more or less arbitrary. In the absence of a definite and well-established standard for classifying tropical storms according to their intensity, it is natural enough that different writers and different observers should have varying standards and obtain different results in their grouping of tropical storms.

Let us take, for example, the tropical storms of the western Pacific during the period 1904–1915. If we apply the term typhoon to those storms that registered a wind velocity of Beaufort scale 12, the average number of typhoons per year is only 9. If, however, the term be extended to include all the well-developed storms, the average number increases to 20.5. If, again, all the cyclonic storms were counted, irrespective of their intensity or degree of development, the number would be 30 or more per year. The frequency of typhoons would be the same as that of the cyclones of the South Indian Ocean, provided only those storms were counted in which winds of hurricane force were recorded. Von Hann took the data with regard to the frequency of typhoons from the works of Algué and Doberck. Judging by the result given by those authorities (see Table 5) it is safe to say that they have included under the term typhoon cyclones of the second order—i. e., storms during which a wind force of Beaufort scale 6 or more was registered.

TABLE 5.—*Seasonal distribution of typhoons, in percentages*

Period	1880–1901[a]	1885–1897[b]	1904–1915	1904–1915	1893–1918[c]	1880–1920[d]
Number of years	22	13	12	12	26	41
January	2	0	1	3	5	4.0
February	0	0	0	1	3	1.9
March	1	0	2	3	3	2.3
April	2	2	2	1	2	2.6
May	5	4	4	4	5.5	5.1
June	9	10	5	4	5.5	6.1
July	16	19	16	14	14	15.4
August	17	18	21	22	15	16.0
September	19	23	19	21	18	18.3
October	14	13	14	17	16	14.4
November	11	9	9	7	8	8.6
December	5	2	6	3	5	5.2
Total number of storms	468	244	247	109	619	917
Number of storms each year	21.3	19	20.5	9	23.8	22.4

[a] Algué, Cyclones of the Far East, Manila, 1904, p. 86.
[b] Doberck, The Law of Storms in the Eastern Seas, Hongkong, 1898, p. 33.
[c] Louis Froc, Atlas of the Tracks of 620 Typhoons, Shanghai, 1920.
[d] S. S. Visher, "Notes on typhoons, with charts of normal and aberrant tracks," MONTHLY WEATHER REVIEW, Nov. 1922, 50: 584–589.

[17] J. Von Hann, "Lehrbuch der Meteorologie" 3d ed., Leipzig, 1915, p. 612.

Table 5 also shows the monthly distribution of typhoons observed during the period 1904–1915. The percentages under column 4 are based on typhoons of the first order alone, while those under column 5 are based upon typhoons of the first and second orders. As a whole, these figures agree well with the percentages as given by Froc, Doberck, and Algué. There is but one discrepancy worthy of note. According to Froc, Doberck, and Algué, the maximum number of storms occurs in the month of September, while according to the present computation it occurs in the month of August. This difference can be partly explained, at least in the case of

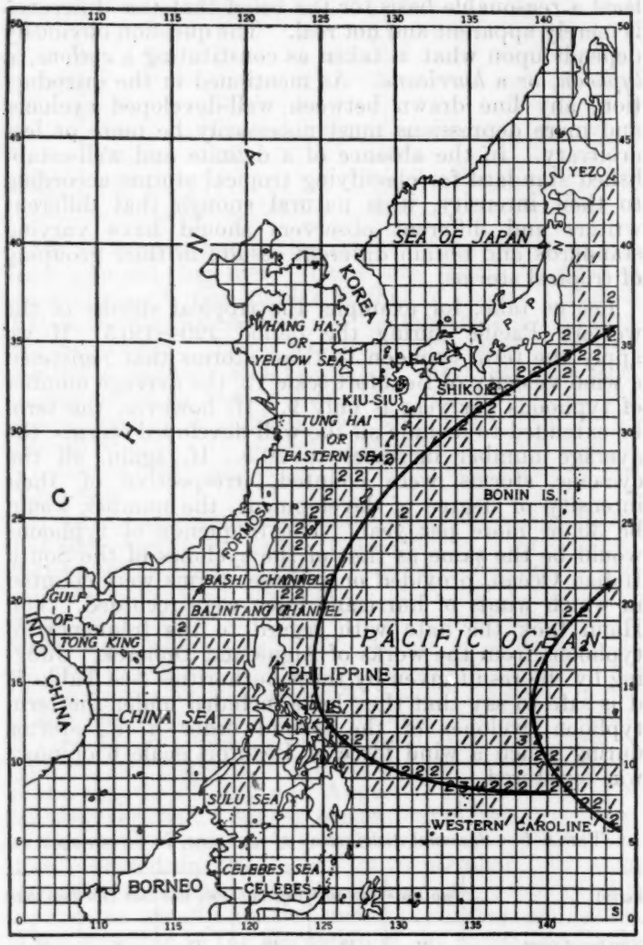

FIG. 1.—Composite tracks of 14 typhoons observed during the months January–April, 1904–1915

Father Algué's figures. We quote here his statement in The Cyclones of the Far East.[18] "In the first place we believe it will be of special interest and practical value to know something of the distribution of cyclones over the different months of the year, so as to find in what month they appear with greatest frequency and what months are free from them. For this purpose we have included those cyclones which have appeared in this archipelago, either crossing it or passing through it for a greater or less distance, and whose trajectory this observation has been able to discover." Thus we see that Father Algué based his result on the typhoons that cross the Philippine Islands, which, as Table 3 shows, have a decided minimum in the month of August, and on those which pass near by the islands. Most of the typhoons of Japan, especially those of type 2a, which do not approach the archipelago, have been omitted. These are, however, just the ones which occur most frequently in the month of August, as shown in Table 3.

The number or percentage of storms in each month, however, has not much significance unless we know the course or track which the cyclones generally pursue. For this purpose, Father Algué plotted the mean tracks of the typhoons of the Far East.[19] While the chart indicates the mean latitude and longitude of origin and of recurvature of typhoons in the different months, and also their average tracks, it does not show their frequency at a given place. Besides, the curves are often too broadly generalized. For instance, very few storms of a particular month will follow exactly the mean track of that month. On the other hand, if we plot all the storm tracks of a given period on one chart, as is sometimes done, the result usually becomes so confused that no satisfactory conclusion can be drawn. To obviate this difficulty, the following scheme has been adopted.

A map of eastern Asia and the western Pacific, on the Mercator projection, has been divided into squares, one degree longitude in width, and one degree latitude in length. Storm tracks of each month during the period of 1904–1915, plotted on maps of the same scale, were then traced on the cross section map, and each time a storm passed a certain square, a mark was made on that square. The total number in each square shows the number of storms that traversed that square during the given period.

Charts 1–7 were constructed according to this plan. Owing to the small number of storms in the months of January to April, inclusive, the tracks for those months were traced on one map. For the same reason the tracks of May and June and those of November and December were combined.

From charts 1–7 it is to be noted that during the first four months of the year the storms occurred mainly in the region limited by latitudes 5°–15° N., and longitudes 120°–140° E. A few reached higher latitudes, and traveled over the Loochoo group. The path of such storms was narrowly limited by the Siberian anticyclone on the one hand, and by the Pacific anticyclone on the other.[20] None of the cyclones approached the continent, and none crossed Japan, although a few passed over the Philippines. The composite storm tracks for the months of May and June are very striking. While maintaining the same general trend of path which characterized the typhoons of the first four months of the year, the May–June track is shifted a little to the northwest. Hence, a good many typhoons traversed the Japanese Islands, and a few reached southern China and the Gulf of Tonking, while the number of typhoons that occurred south of latitude 10° N. was comparatively small. The control exercised by the high-pressure area in the Pacific, over the Bonin Islands, is still much in evidence.

In the month of July the area covered by the storm tracks becomes much more extensive than in the preceding months. These tracks now extend still further to the north and west, until they reach the limits of the map in both directions. Most of the storms, however, are concentrated in latitudes 15°–30° N., and longitudes

[18] Algué: Loc. cit., p. 86.

[19] Algué: Loc. cit., see plate opposite, p. 146.

[20] For pressure distribution of eastern Asia in different months, see Louis Froc's Atlas of Tracks of 620 Typhoons.

115°–135° E. In the Pacific west of longitude 145°, and north of latitude 10° N., only the Bonin Islands and their immediate neighborhood are immune from typhoons, owing, no doubt, to the influence of the Pacific HIGH. The storm tracks begin to shift eastward in the month of August, so that no part of the Pacific west of longitude 145° E. and north of latitude 10° is then free of typhoons. Fewer storms reach the continent and, when they do, they do not penetrate as far as in July. In Japan, however, the reverse is true. More storms traversed these islands than during the preceding month. Attention is called to the fact that the island of Luzon was practically free from cyclones. In the Bashi and the Balintang channels, immediately north of Luzon, storms were very frequent.

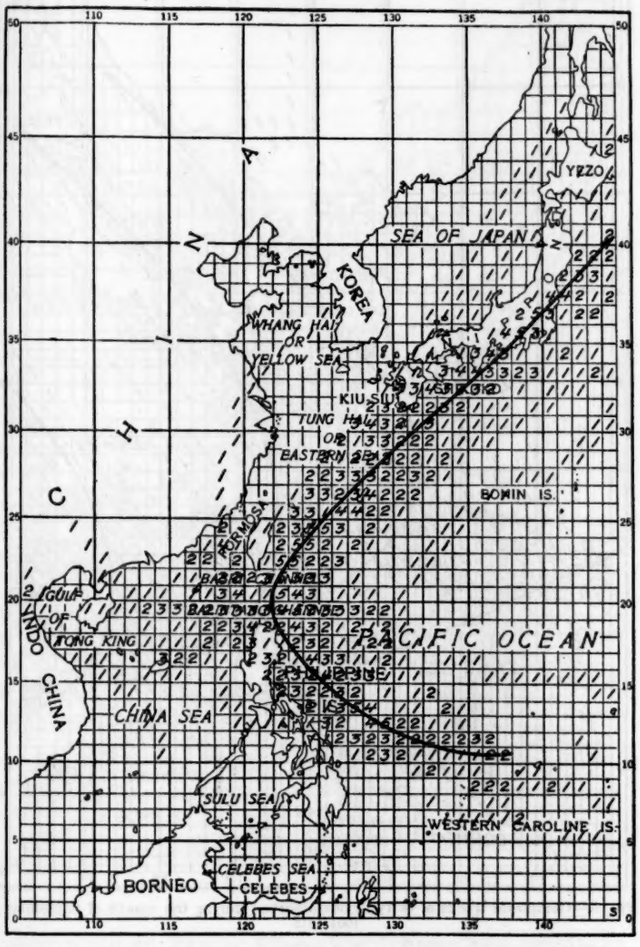

FIG. 2.—Composite tracks of 24 typhoons observed during the months May-June, 1904–1915

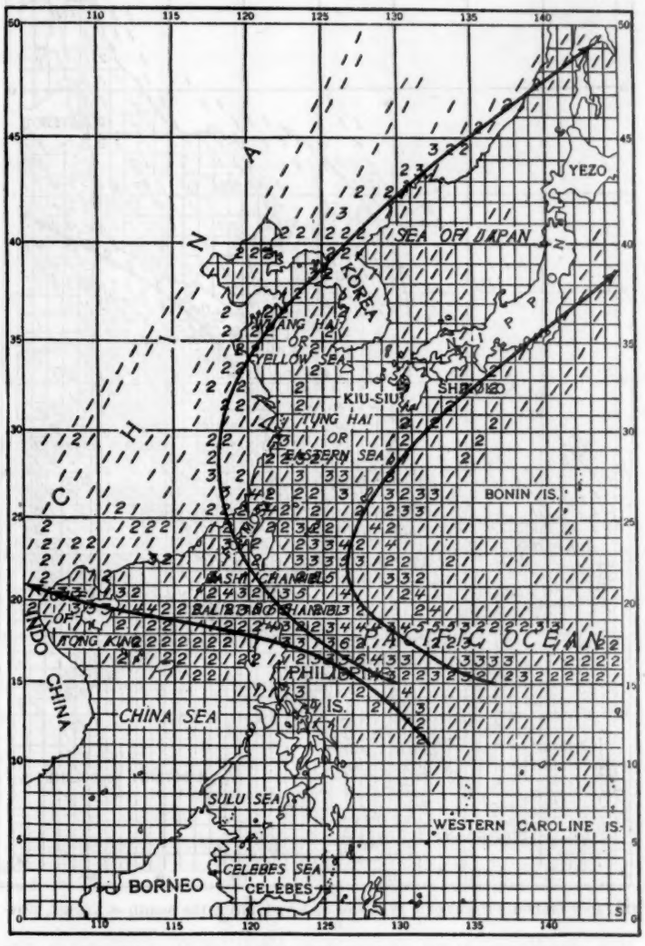

FIG. 3.—Composite tracks of 39 typhoons observed during the month of July, 1904–1915

Indeed, these channels seem to be the favorite highways of cyclones throughout the year.

In the month of September the storm path begins to shift southward, so that the frequency of cyclones south of latitude 15° N. increases considerably, while the number of cyclones occurring north of latitude 30° N. becomes comparatively few. There were more storms in the China Sea in this month than in any other month. The tendency of the storm tracks to be displaced southward and eastward, which begins in September, is still more marked in October. The majority of storms is concentrated in the region south of latitude 20° N. The island of Mindanao, and the part of the China Sea south of latitude 13°, which were not visited by the vortices of typhoons during the preceding months, are now frequented by them. No typhoons reach the Chinese coast north of latitude 25° N., although quite a few cross Japan. The typhoon tracks retreat still more to the southeast in the month of November and December, this fact being undoubtedly due to the advance of the continental anticyclones. The northern limit of the typhoon tracks in these two months approximates the isobar 762 millimeters (30 inches) which embraces Japan, the island of Formosa, and passes through Hainan. A considerable number of the typhoons traveled on a course south of latitude 15° N.

From the foregoing discussion, it will be evident that typhoon tracks are controlled by the four "centers of action" in the Far East, viz, the Siberian and the Pacific anticyclones, and the Aleutian and Indian cyclones. Of the two high-pressure areas, the Siberian anticyclone is the more effective. Not only is it far more intense than the Pacific HIGH, but the continent of Asia itself serves as an obstacle in the path of a moving typhoon. Even in summer, typhoons do not penetrate far into the continent, although the lowest pressure is to be found over the land at that season. Many storms find their way into the Aleutian LOW, but few, if any reach the Indian LOW, for they break up as soon as they go on shore on the coast of Indo-China.[21]

[21] For typhoon tracks also compare Algué: Loc. cit., chap. 8, pp. 78–83.

Among the different authorities who have touched upon the subject of monthly variation of typhoon tracks, Father Chevalier probably has stated it the most clearly. He says:[22] "I do not believe the trajectories of typhoons to be irregular; they are bound by laws, many of which are still unknown to us, but not a few can be established with some accuracy. To proceed more clearly in this determination, we have first to divide the typhoons into several classes. The first way of division is to classify them according to the time of their occurrence, into the typhoons of May, typhoons of June, typhoons of July, and so forth. And this way of classifying them, simple as it is, is not so bad for the present purpose. Indeed the periods of the year are the first principle on which apparently the variation of typhoon trajectories depends. "The trajectories of the typhoons of the different months are then described, beginning with the month of May, which, according to Father Chevalier, is the first month of the typhoon season. Father Chevalier divided the typhoon tracks of May and June into three classes: (1) those which originate northeast of the Philippines, recurving toward the Pacific; (2) those which originate nearer to the Philippines and travel westward or northwestward toward the Gulf of Tonking; and (3) those which originate in the Pacific, enter the northern part of the China Sea, recurve southeast of Formosa, and take a north or northeast course toward Japan. It is to be observed on the chart of the composite tracks for the months of May and June, that the storms of the third class predominate over the other types during the period 1904–1915.

With regard to the typhoons of July, August, and September, Father Chevalier says: "Though the season commences with May, typhoons are rare before July. With July they begin to be more frequent and also, generally, to reach the Chinese coast north of Hongkong instead of traveling toward the Tonking Gulf; and if the season be much advanced into August, there is more chance of their reaching a higher latitude. Hence they are seen to reach the estuary of the Yangtze River before the middle of July. The typhoons traveling thus toward the Chinese coast are those which during May and June traveled rather to the Tonking Gulf, namely, those which originate nearer to the Philippine Islands east or northeast of Luzon." We have seen in Table 4 that typhoons go to the Tonking Gulf most frequently in the months of September and October, but rarely in the months of May and June. It will also be seen later that the typhoons which go toward the Chinese coast i. e., those of types 1a and 1b, originate farther to the

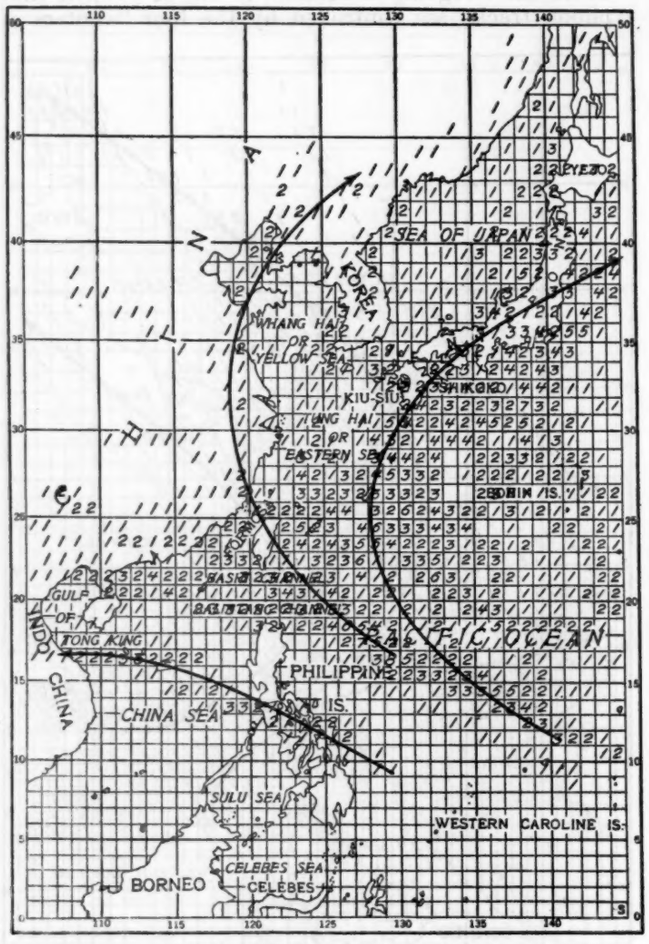

FIG. 4.—Composite tracks of 51 typhoons observed during the month of August, 1904–1915

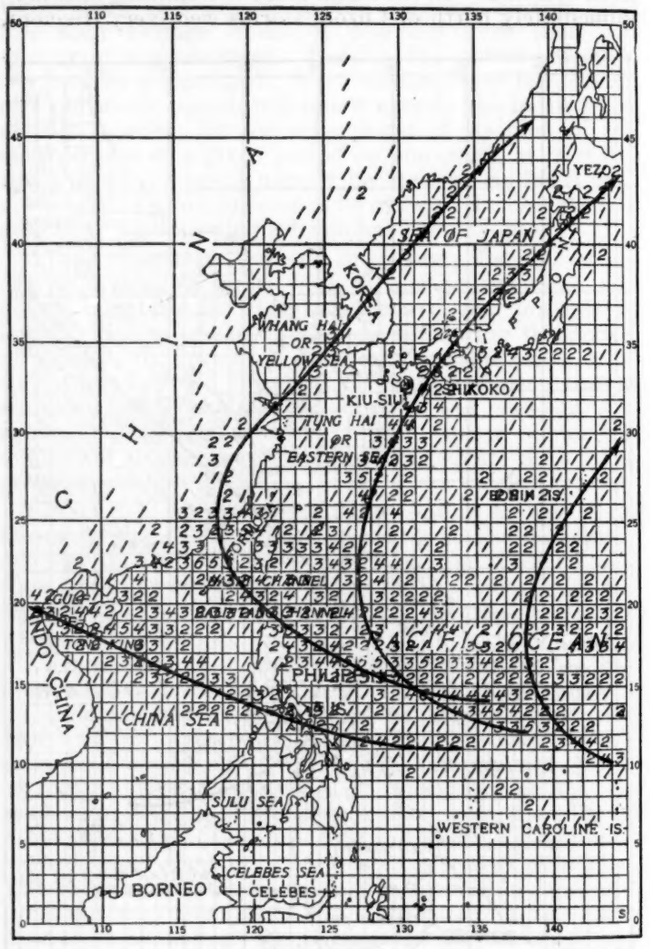

FIG. 5.—Composite tracks of 46 typhoons observed during the month of September, 1904–1915

[22] Chevalier, The Typhoons of the Year 1893, Shanghai, pp. 87–97.

east than do those which travel over Luzon toward the Gulf of Tonking, or those of type 3b. On the other hand the storms that pass through the Balintang Channel and travel westward or southwestward to the Gulf of Tonking or Annam, or those of type 3a, originate in the same region as the typhoons of type 1a and 1b. This proves that typhoons of types 1a and 1b and those of 3a belong to the same class, but owing to the high pressure over the continent toward the end of September or in October, the storms are obliged to travel westward or southwestward on reaching the Balintang Channel.

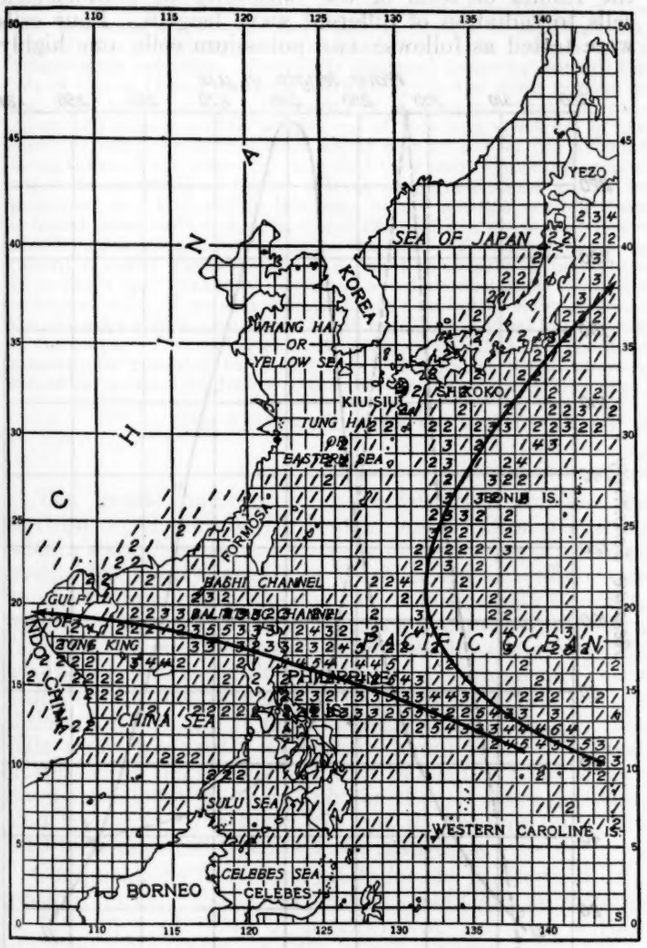

FIG. 6.—Composite tracks of 36 typhoons observed during the month of October, 1904–1915

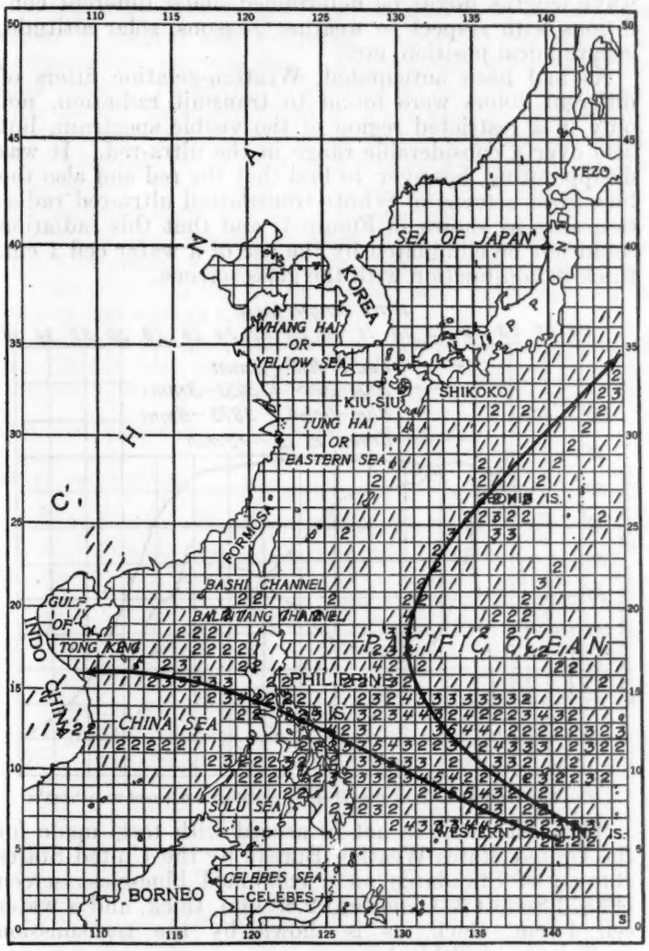

FIG. 7.—Composite tracks of 37 typhoons observed during the months November-December, 1904–1915

According to Father Chevalier, "From the middle of September the typhoons cease coming to Shanghai, but, they do not cease so soon to leave the Formosa Channel, especially the south of it. The more advanced October is, the freer is the north of the channel from typhoons, and the more surely do the typhoons move toward the Tonking Gulf, or recurve to a northeastward direction south of Formosa." The typhoons which recurve in a northeastward direction south of Formosa belong to type 4c, and as shown in Table 4 come in the months of April, May, October, November, and December.

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Father Chevalier's statement with regard to the typhoons of November and December is as follows: "With November, the typhoons cease completely to rise to latitudes higher than 20°. Their formation takes place farther in the south, and the more the month of November is advanced, the farther south do they originate. This period of the year is the period of Annamese typhoons. The typhoons crossing the Philippine Islands generally traveled westward, and therefore go directly toward Annam, the farthest place they reach toward north is the Tonking Gulf. It is during this period that the abnormal southwest direction is sometimes observed." It is to be added that typhoons sometimes take a southwestward direction in the northern part of the China Sea, not only in the months of November and December, but also in October and even September.[23]

With the exception of a few minor discrepancies Father Chevalier's description of the typhoon tracks of the different months agrees remarkably well with the data given on charts 1–7.

[23] Louis Froc: Loc. cit., Shanghai, 1920, p. 1.

(To be concluded in the January, 1925, REVIEW)

DORNO ON THE TECHNIQUE OF THE MEASUREMENT OF SOLAR RADIATION IN RESTRICTED SPECTRAL REGIONS [1]

By HERBERT H. KIMBALL
[U. S. Weather Bureau, Washington, D. C., December 17, 1924]

The first part of the paper, Heft 8, 234–239, gives the results of spectro-analytical investigations of the transmissibility of different glass and Wratten-gelatine filters for radiation of different wave lengths. Such filters have been employed at Davos and elsewhere to isolate solar radiation in restricted regions of the spectrum, so that the intensity and variability of the radiation at different wave lengths might be determined under different conditions with respect to weather, seasons, solar altitude, geographical position, etc.

As had been anticipated, Wratten-gelatine filters of different colors were found to transmit radiation, not only in a restricted region of the visible spectrum, but also over a considerable range in the ultra-red. It was disappointing, however, to find that the red and also the blue glass screens of Schott transmitted ultra-red radiation also, as shown in Figure 1, and that this radiation could not be eliminated by the use of a water cell 1 cm. thick in conjunction with the glass screens.

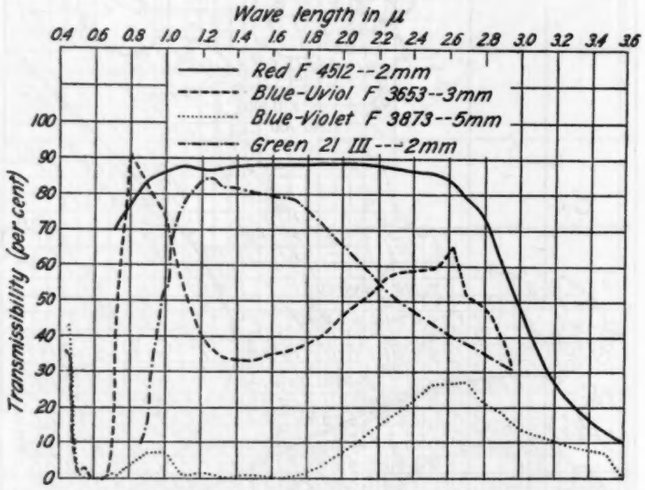

Wave length in μ
0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6
Red F 4512--2mm
Blue-Uviol F 3653--3mm
Blue-Violet F 3873--5mm
Green 21 III---2mm
Transmissibility (per cent)
100 90 80 70 60 50 40 30 20 10 0

FIG. 1.—Transmissibility of glass filters for radiation of different wave lengths

This last result is not in accord with tests made for the United States Weather Bureau by the United States Bureau of Standards on a combined blue-glass screen (F3873 Schott & Genossen) 2.58 mm. thick, and a water cell 1 cm. thick, as is shown by the transmission coefficients of Table 1.

TABLE 1.—*Transmission of combined blue-grass screen (No. F3873 Schott & Genossen) and water cell 1 cm. thick. Bureau of Standards test No. 3808*

Wave length, μμ	348	350	360	370	380	390	400	410	420	430
Transmission, per cent	0	1	4	11	19	28	30	30	31	31

Wave length, μμ	440	450	460	470	480	490	500	510	565	706
Transmission, per cent	31	30	24	18	11	6	3	1	0.01–	0.02–

Wave length, μμ	800	1,000	1,200	1,400	1,600	1,800	2,000
Transmission:							
Blue glass, per cent	0.0	0.0	0.0	0.0	0.0	0.9	2.6
Water cell, per cent	82.0	68.0	31.5	5.8	2.0	0.0	[1] 0.0
Combined cell	0.0	0.0	0.0	0.0	0.0	0.0	[1] 0.0

[1] Out to 9,000 μμ.

As is pointed out by the author, the results of his tests indicate that caution must be used in interpreting measurements of the intensity of restricted areas of the solar spectrum where color screens have beeen used. See for example his paper in the MONTHLY WEATHER REVIEW, October, 1922, vol. **50**: 515.

This does not apply to measurements by photoelectric cells, however, since these cells are not sensitive to ultra-red radiation.

The second part of the paper, Heft 9, 269–276, gives the results of tests of the sensibility of photoelectric cells to radiation of different wave lengths. Four cells were tested as follows: two potassium cells, one highly evacuated, and one filled with argon gas; two cadmium cells, one large and the other small, the large one obtained after the war, and the small one before the war.

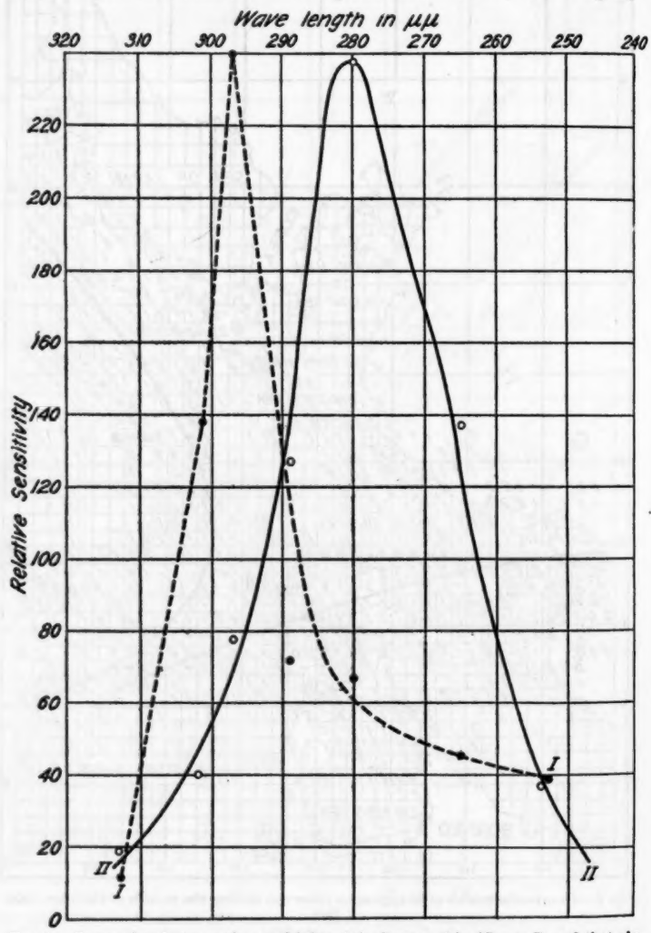


FIG. 2.—Comparison between the sensitivity of the human skin (Curve I) and that of a cadmium cell (Curve II). NOTE.—This cell, obtained by Dorno in 1922, is less sensitive to short-wave radiation than is a similar cell obtained before the war. This is attributed by Dorno to a difference in the glass in the bulbs

The results show that the gas-filled potassium cell has its maximum of sensibility at a slightly longer wave length than the evacuated cell, or at about 450μμ. The curves of sensibility of the two cadmium cells are quite dissimilar. The one procured before the war is relatively more sensitive to short-wave radiation than the other, their maxima occurring at about 265μμ and 280μμ, respectively. The difference is attributed to the difference in transmission of the uviol glass of which the walls of the cells are made, and from this it is concluded that the true maximum of the cadmium cell, if uninfluenced by the glass of the cell walls, would be at

[1] C. Dorno, mit Beträgen von K. W. Meissner und W. Vahle: Zur Technik der Sonnenstrahlungsmessungen in einzelnen Spectralbezirken (Filterdurchlässigkeit, Zellenempfindlichkeit, Michelson-Actinometer). Met. Zeit., 1924, Heft 8: 234-239; Heft 9: 269-277.

a much shorter wave length than that given by these tests. It follows that the cadmium cell promises to be of great value where measurements of ultra-violet radiation (of shorter wave length than 313$\mu\mu$) are desired. It is shown that this is the case in radio-therapy, since it is this short-wave radiation that is most active in producing pigmentation of the skin.

Upon this point Dorno says:

> Correct dosage is of the greatest importance in all radio-therapy; so long as the dosage is based upon the degree of pigmentation of the skin there is need for an instrument giving measurement of intensity exclusively for that spectral region which causes pigmentation. In Figure 2 are drawn (1) the curve of sensitivity of the skin according to Hausser and Vahle in degrees of pigmentation, and (2) the sensitivity of the cadmium cell, both determined by quartz lamp radiation. Curve I is displaced somewhat toward the left of Curve II and descends more slowly in the lower portion of the right-hand branch. However, it is apparent that the cadmium cell almost exactly singles out of this long spectrum of the mercury lamp, extending from about 600 to 230 $\mu\mu$ (no account being taken of the ultra-red) only that very narrow spectral section which is essential, so far as actions of pigmentation are to be measured, and that within this very narrow spectral section there is found practically the same distribution of energy as that desirable for evaluating the action upon the skin. Therefore, for use in radiation cures, which takes into account the degree of pigmentation, there can hardly be invented a better dosimeter than the cadmium cell. If we attach importance to a better coincidence in the two curves of Figure 2, which will hardly be of great importance in the matter of correct dosage, it is presumable that this could be attained by choosing for a cell wall a uviol glass which offers a somewhat greater hindrance to the passage of the ultra-violet rays.

Part 3 of the paper, Heft 9 : 276–277 is devoted to a discussion of the Michelson bimetallic actinometer, which has been in use at Davos with satisfactory results since 1909, when two of these instruments were purchased from Moscow. A third was obtained in 1914, likewise from Moscow, and with the three instruments more than a million measurements have been made, at the surface of the earth from sea level to elevations of 3,500 meters, at sea, and on balloon flights, without damage to the instruments, and with little change in their standardization constants. Dorno speaks of them as reaching a stable condition within 10 or 15 seconds after exposure, and following closely all variations in atmospheric transmission. A not irrelevant temperature correction is required by the first two instruments belonging to the type described in Physikalische Zeitschrift, 1908, page 18, and following pages, whereas the third, one belonging to the type described in the Meteorologische Zeitschrift, 1913, page 577, does not show any greater dependence upon the temperature than that cited with examples by Professor Michelson, being thus quite extraordinarily independant of temperature oscillations.

The data relating to the various tests are presented in tables and also in diagrams.

In preparing this summary the writer has made use of an English text prepared by Dorno. This text included Figure II which does not appear in the original paper.

THE PROBABILITIES OF 0.10 INCH, OR MORE, OF RAINFALL AT SPRINGFIELD, ILL.

By WALTER F. FELDWISCH
[Weather Bureau, Springfield, Ill., August 27, 1924]

The great majority of rain-insurance policies are written on the basis of 0.10 inch precipitation occurring within a specified time. Those who contemplate insuring events frequently inquire of Weather Bureau officials as to what hours during the day rain is most likely to occur, and they especially desire to know the probability of a fall of 0.10 inch or more. Computations showing the average relative depth of fall for each hour are very valuable, but the rate of fall may vary decidedly for the different hours and it may be possible that though rain falls more frequently at certain hours than at others, nevertheless the showers at that particular time of day have a tendency to be so light or of such short duration that frequently the total will not be brought up to the 0.10 inch required to collect the insurance.

Computations have been made for the Springfield, Ill., station, showing the actual percentage of times an amount of 0.10 inch or more of precipitation occurred within specified time limits, and the result is shown in Table 1. As would naturally be supposed, the table indicates that the greater the number of hours included in a period the greater becomes the probability of 0.10 inch within the specified hours for the different times of the day. So, while in May, for instance, in considering six-hour periods, one inspecting the total hourly falls as shown by Table 2 and Figure 1, and the percentages as shown by Table 3, might be inclined to think the hours from midnight to 6 a. m. better for the insured from a monetary point of view than those from 12 noon to 6 p. m. by a margin of 2 to 1, provided rates for all hours are equal, nevertheless this supposition is not borne out by the figures of Table 1. Furthermore, Table 1 shows that in May there is, on the average, less probability of 0.10 inch occurring within six hours following the individual hours 6 a. m. to 11 a. m. than for those of 12 noon to 6 p. m., while Table 3 shows that a slightly greater percentage of the 24-hour amount occurs between 6 a.m. and 12 noon

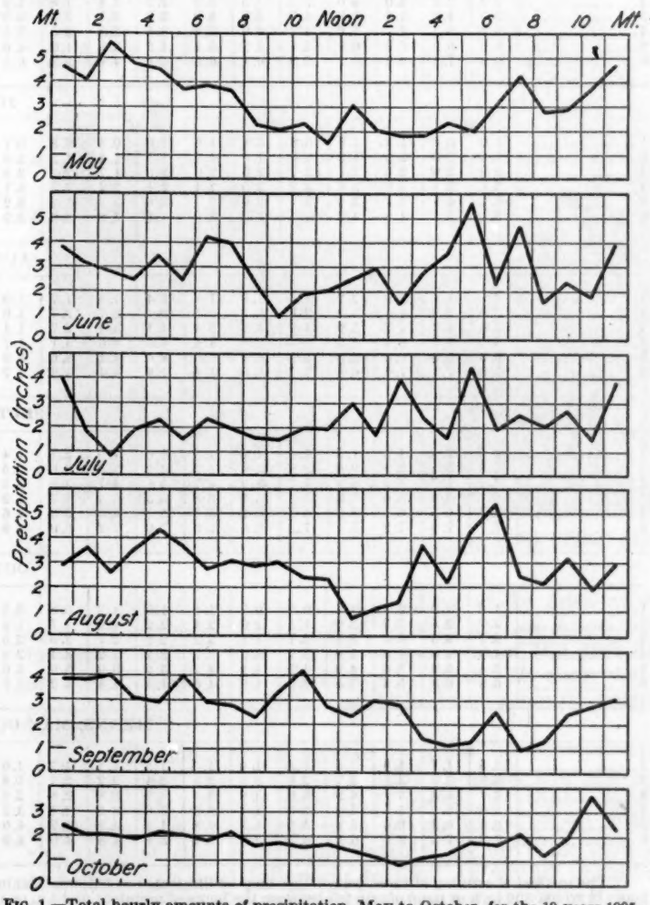


FIG. 1.—Total hourly amounts of precipitation, May to October, for the 19 years 1905–1923, inclusive, at Springfield, Ill. Data from Table 2

than between 12 noon and 6 p. m. Other instances of a similar character, though hardly so pronounced, may be seen in other months.

A careful consideration of Table 1 may sometimes prove of value in answering inquiries as to the local forecast on days when the precipitation forecast is what is termed "indefinite." A judicious use of such a table in connection with observed local conditions may sometimes enable the forecaster to give information of value in regard to what hours precipitation is most likely to occur during the period of such "indefinite" forecast. Moreover, under conditions when the occurrence of any precipitation appears doubtful, or if the precipitation area is moving as a narrow strip of intermittent scattered showers, if the local forecast official can determine pretty definitely at what hour the conditions can be expected to be most favorable for precipitation at his station, the table may be an aid in deciding whether or not rain should be forecast. Thus, if barometric or other conditions most favorable for precipitation are due to pass over the station at an hour when the table shows rain to occur infrequently, the wording of the forecast may differ somewhat from that given when it is seen that conditions most favorable for precipitation will pass over the station at a time when the table shows a relatively high frequency of precipitation.

TABLE 1.—*Percentage frequency of the occurrence of 0.10 inch or more precipitation within 1, 2, 3, 4, 5, and 6 hours beginning at midnight, 1 a. m., 2 a. m., etc., for 24 hours*[1]*, at Springfield, Ill. (years 1905-1923, inclusive)*

MAY

Period (hours)	Period beginning at— A. M.												P. M.												Mean
	Midnight	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	
1	2.2	3.1	2.7	2.4	1.9	2.5	1.4	1.2	0.7	1.2	0.8	1.5	1.2	0.7	1.0	1.4	1.2	1.9	2.4	1.2	1.2	1.7	2.9	2.2	1.8
2	4.9	5.1	4.2	4.1	4.4	3.4	2.5	2.4	1.9	2.0	2.0	2.2	2.5	2.0	2.9	2.5	2.9	3.4	3.1	2.7	2.7	4.1	4.6	3.1	3.2
3	6.4	6.3	5.9	6.3	5.1	4.1	3.4	3.1	2.5	2.9	2.5	3.2	3.9	3.7	3.7	3.7	4.4	3.9	4.6	4.2	4.9	5.3	5.1	5.4	4.6
4	7.5	7.0	8.3	7.0	5.8	5.1	4.6	4.1	3.4	3.6	3.7	4.6	5.4	4.4	4.6	5.4	5.1	5.6	6.3	5.9	5.9	5.9	7.1	6.6	5.6
5	8.5	9.0	8.7	7.6	7.1	5.9	4.9	4.8	3.9	4.6	4.8	5.9	6.1	5.3	6.1	5.8	7.0	7.1	7.8	6.8	6.6	8.1	8.3	8.0	6.6
6	10.5	9.8	9.2	8.5	7.8	6.3	5.6	5.3	4.9	5.6	6.1	6.6	7.1	6.8	6.5	7.6	8.5	8.8	8.5	7.3	8.8	9.3	9.5	8.5	7.6
JUNE																									
1	1.4	1.4	1.2	1.8	1.1	1.6	2.1	0.9	0.5	0.9	1.1	0.9	1.1	0.7	1.6	1.4	1.9	1.2	1.2	0.7	0.5	1.1	1.9	0.9	1.2
2	2.3	2.8	3.0	3.0	2.5	3.5	3.0	2.3	1.4	1.8	1.9	1.8	1.4	2.1	3.2	2.8	2.5	2.3	2.1	1.1	1.6	2.3	2.1	2.3	2.3
3	3.3	4.2	4.0	3.9	4.0	4.2	4.0	2.8	2.1	2.5	3.0	2.3	3.0	3.5	4.6	3.5	3.5	3.0	2.3	2.3	2.5	2.3	3.2	3.0	3.2
4	4.7	5.3	4.7	5.6	4.7	4.9	4.4	3.5	2.8	3.5	3.5	4.0	4.4	4.9	5.4	4.7	4.4	3.9	3.3	3.2	2.5	3.2	3.5	4.2	4.0
5	5.6	6.0	6.3	6.1	5.4	5.3	5.1	4.2	3.9	4.0	4.9	5.4	5.8	5.8	6.5	5.4	4.4	4.2	4.2	3.3	3.3	3.5	4.6	5.4	4.9
6	6.3	7.5	6.8	6.7	5.8	6.1	6.0	5.1	4.4	5.3	6.5	6.8	6.5	6.8	7.4	5.4	5.4	5.1	4.4	4.2	3.7	4.6	5.6	5.8	5.8
JULY																									
1	1.0	0.5	1.2	1.0	0.8	0.8	1.0	1.0	0.8	0.8	0.7	1.7	0.5	0.7	0.7	0.8	1.0	1.2	1.0	1.4	1.2	0.8	1.5	1.2	1.0
2	1.5	2.0	2.0	1.5	1.9	1.5	1.5	1.5	1.4	1.2	2.0	2.2	1.0	0.8	1.5	1.7	1.7	2.0	2.0	2.2	2.0	2.2	2.4	2.4	1.7
3	2.9	2.9	2.5	2.7	2.7	2.0	2.0	2.0	1.7	2.2	2.5	2.7	1.2	1.7	2.3	2.4	2.2	2.9	2.7	3.1	3.4	3.1	3.4	2.9	2.5
4	3.6	3.4	3.6	3.4	3.2	2.5	2.4	2.4	2.7	2.7	3.1	2.9	2.0	2.4	2.9	3.1	3.1	3.6	3.6	4.2	4.2	3.9	3.7	4.1	3.2
5	4.1	4.4	4.4	3.9	3.7	2.9	2.7	3.6	3.1	3.2	3.2	3.7	2.7	3.2	3.4	3.9	3.7	4.4	4.9	5.1	5.3	4.4	4.9	4.8	3.9
6	5.1	5.1	4.9	4.2	4.1	3.2	3.9	4.1	3.6	3.6	3.9	4.2	3.6	3.7	4.2	4.8	4.6	5.8	5.8	5.8	5.6	5.4	5.6	5.3	4.6
AUGUST																									
1	1.7	1.4	2.0	2.2	1.7	1.5	1.4	1.4	1.4	1.7	1.0	0.3	0.5	0.8	1.2	1.2	1.5	2.5	1.0	1.2	1.5	1.5	1.7	1.4	1.4
2	2.5	2.9	4.1	3.1	2.7	3.1	2.5	2.5	2.7	2.7	1.0	0.7	1.0	2.0	2.0	2.4	3.6	3.2	2.0	2.4	2.4	2.5	2.2	2.2	2.4
3	3.6	4.7	4.7	3.9	4.2	4.2	3.4	4.1	3.4	2.7	1.4	1.2	2.0	3.1	3.6	4.4	4.2	4.1	3.1	3.6	3.6	2.9	2.9	2.9	3.4
4	5.6	5.3	5.4	5.3	5.4	5.1	4.8	4.6	3.6	3.1	1.7	2.2	2.9	4.4	5.6	5.3	5.4	5.1	4.2	4.6	3.9	3.6	3.4	3.7	4.4
5	6.3	5.9	6.6	6.3	5.9	6.3	5.3	4.6	4.1	3.6	2.9	3.2	4.2	6.5	6.5	6.5	6.1	6.1	5.1	4.9	4.6	4.1	4.2	5.3	5.3
6	7.0	7.1	7.6	6.8	7.1	6.8	5.3	4.9	4.4	4.8	4.2	4.4	6.3	7.0	7.5	7.1	7.3	7.0	5.4	5.6	5.1	5.1	5.8	5.9	6.1
SEPTEMBER																									
1	1.9	2.5	1.6	1.9	1.6	1.2	1.8	1.6	1.9	2.1	1.4	1.1	1.6	1.8	0.4	0.5	0.5	1.2	0.5	0.9	1.6	1.4	1.1	1.9	1.4
2	3.9	3.5	3.3	2.6	2.8	3.0	3.2	3.2	3.9	3.0	2.5	2.6	2.5	1.9	1.2	1.2	1.8	1.4	1.2	2.1	2.6	2.3	3.2	4.0	2.6
3	4.9	4.7	4.2	4.4	4.2	3.9	4.7	4.6	4.7	3.9	3.5	3.5	2.6	2.6	1.8	2.5	2.1	1.9	2.6	3.3	3.3	4.0	4.4	4.9	3.7
4	6.1	5.4	5.6	5.3	5.1	5.1	5.8	5.3	5.4	4.7	4.2	*3.7	3.2	3.2	2.8	2.8	2.6	3.2	3.5	3.9	5.6	5.3	5.3	5.8	4.6
5	6.7	6.5	6.5	6.1	6.5	6.1	6.3	5.1	6.3	5.8	4.6	4.2	3.9	4.6	3.2	3.5	4.0	4.0	4.2	5.8	6.5	6.1	6.1	6.8	5.4
6	7.7	7.5	7.2	7.4	7.2	6.8	7.0	7.0	7.2	6.0	4.9	4.9	4.9	4.9	3.9	4.6	4.7	4.6	6.1	6.8	7.4	6.7	7.0	7.2	6.3
OCTOBER																									
1	1.2	1.2	0.7	1.4	0.5	0.7	1.5	1.0	1.2	0.8	0.8	0.8	0.7	0.3	0.7	0.8	0.5	0.8	1.0	0.5	1.0	1.9	1.2	1.4	1.0
2	2.7	2.5	2.2	2.0	1.5	2.0	2.4	2.2	1.9	1.7	1.9	1.9	1.2	1.4	1.5	1.9	1.9	2.0	1.9	2.2	3.6	3.4	3.1	2.2	2.2
3	3.7	3.9	3.1	3.1	3.1	3.1	3.2	2.7	2.7	2.5	2.5	2.2	2.0	1.7	2.0	2.9	2.5	2.4	3.1	4.1	4.4	4.8	3.6	3.7	3.1
4	4.9	4.8	4.4	4.8	3.7	3.6	3.7	3.2	3.2	3.1	2.9	3.1	2.2	2.4	3.1	3.6	3.1	3.7	4.8	4.9	5.6	5.4	5.1	4.6	3.9
5	5.4	5.8	5.6	4.9	4.2	4.1	4.2	3.9	3.9	3.9	3.6	3.2	2.7	3.1	3.7	4.1	4.8	5.6	5.6	5.8	6.1	6.1	5.4	5.8	4.6
6	6.8	6.8	5.8	5.4	4.6	4.6	4.6	4.4	4.4	4.2	3.7	3.7	3.6	3.9	4.2	5.1	6.3	6.3	6.6	6.3	6.8	6.5	6.6	6.3	5.3
MEANS, MAY-OCTOBER, INCLUSIVE																									
1	1.6	1.7	1.6	1.8	1.3	1.4	1.5	1.2	1.1	1.2	1.0	1.0	0.9	0.8	0.9	1.0	1.1	1.5	1.2	1.0	1.2	1.4	1.7	1.5	1.3
2	3.0	3.1	3.1	2.7	2.6	2.8	2.5	2.4	2.2	2.1	1.9	1.9	1.6	1.7	2.0	2.1	2.4	2.4	2.0	2.1	2.5	2.8	2.9	2.7	2.4
3	4.1	4.4	4.1	4.0	3.9	3.6	3.4	3.2	2.8	2.8	2.6	2.5	2.4	2.7	3.0	3.2	3.2	3.0	3.1	3.4	3.7	3.7	3.8	3.8	3.4
4	5.4	5.2	5.3	5.2	4.6	4.4	6.3	3.8	3.5	3.4	3.2	3.4	3.4	3.6	4.1	4.2	4.0	4.0	4.3	4.4	4.6	4.6	4.7	4.8	4.4
5	6.1	6.3	6.4	5.8	5.5	5.1	4.8	4.4	4.2	4.2	4.0	4.3	4.2	4.8	4.9	4.9	5.0	5.2	5.3	5.3	5.4	5.4	5.6	6.0	5.1
6	7.2	7.3	6.9	6.5	6.1	5.6	5.4	5.1	4.8	4.9	4.9	5.1	5.3	5.5	5.6	5.8	6.1	6.3	6.1	6.0	6.2	6.2	6.7	6.5	5.9

[1] The method of arriving at these percentages may be illustrated as follows: Taking the first entry under midnight, 2.2 per cent, this was obtained by counting the number of hours in which 0.10 inch or more of rain fell between the hours of midnight and 1 a. m. in May. In the 19 years this occurred 13 times. As there are 31 days in May, multiplying 31 by 19 gives 589 as the possible number of hours in which 0.10 inch or more could have occurred; then dividing the actual number (13) by the possible number (589), the result is 2.2 per cent.

TABLE 2.—*Total hourly amounts of precipitation, May to October, for the 19 years 1905-1923, inclusive, at Springfield, Ill.*

	Hour beginning at—																						
	A. M.												P. M.										
	Mid-night	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11
May	4.64	4.04	5.62	4.77	4.54	3.68	3.86	3.66	2.20	2.04	2.28	1.47	3.05	2.03	1.79	1.83	2.32	2.00	3.15	4.27	2.77	2.87	3.78	4.67
June	3.81	3.13	2.84	2.49	3.43	2.47	4.19	3.96	2.23	.95	1.87	2.00	2.44	2.95	1.44	2.75	3.53	5.65	2.26	4.62	1.49	2.36	1.70	3.87
July	3.96	1.85	.85	1.94	2.30	1.52	2.33	1.93	1.57	1.47	1.96	1.95	3.00	1.64	3.98	2.36	1.57	4.47	1.96	2.47	2.04	2.65	1.52	3.79
August	2.90	3.57	2.60	3.55	4.29	3.68	2.74	3.04	2.88	3.02	2.41	2.32	.69	1.11	1.39	3.62	2.14	4.21	5.37	2.42	2.13	3.16	1.90	2.92
September	3.81	3.81	3.97	3.07	2.89	3.97	2.87	2.74	2.26	3.29	4.18	2.70	2.33	2.98	2.79	1.40	1.12	1.27	2.52	.99	1.30	2.41	2.75	3.02
October	2.43	2.05	2.07	1.86	2.15	2.04	1.86	2.15	1.62	1.75	1.59	1.68	1.41	1.18	.86	1.16	1.32	1.78	1.68	2.16	1.21	1.98	3.68	2.29
Mean	3.59	3.08	2.99	2.96	3.27	2.89	2.98	2.91	2.13	2.09	2.38	2.02	2.15	1.98	2.04	2.02	2.00	3.23	2.82	2.82	1.82	2.57	2.56	3.43

TABLE 3.—*Percentage of monthly precipitation occurring during 6-hour periods, May to October, inclusive, Springfield, Ill.*

Month	Midnight to 6 a. m.	6 a. m. to noon	Noon to 6 p. m.	6 p. m. to midnight	Month	Midnight to 6 a. m.	6 a. m. to noon	Noon to 6 p. m.	6 p. m. to midnight
	Per cent	*Per cent*	*Per cent*	*Per cent*		*Per cent*	*Per cent*	*Per cent*	*Per cent*
May	34	19	17	30	September	32	27	19	22
June	27	20	27	26	October	28	23	18	31
July	19	22	29	30					
August	30	21	26	23	Mean	29	22	22	27

HOURLY RAINFALL AT LOS ANGELES, CALIF.

By GEORGE M. FRENCH
[Weather Bureau, Los Angeles, Calif.]

During the past year or two there has been considerable discussion, in connection with the subject of rain insurance, as to the periods of the day in which the greatest and least frequency of rainfall occurs. It has therefore occurred to the writer that it might be of interest to obtain definite information on the subject by making an analysis of the records of hourly rainfall at Los Angeles. At the same time it appeared to be worth while to determine the hours in which the greatest and least amounts of rain fell. The results of this investigation are set forth in the following note.

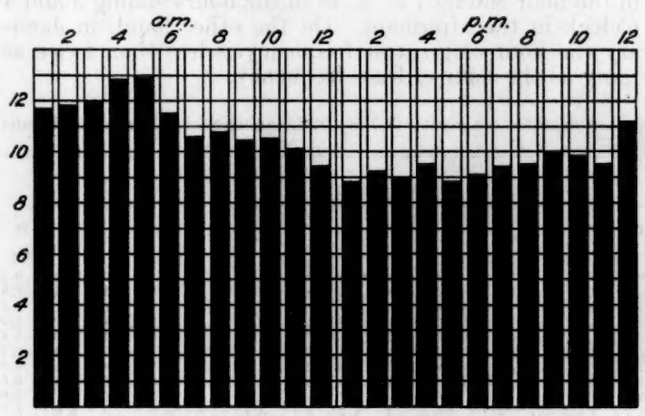


FIG. 1.—The annual average frequency of precipitation (0.01 of an inch or more) for each hour of the day at Los Angeles, Calif., 1905 to 1913, inclusive

It appeared to be the general belief of those with whom the subject was discussed that rain at Los Angeles occurred most frequently and in greatest amount during the night. If we designate 6 p. m. to 6 a. m. as night and 6 a. m. to 6 p. m. as day, this belief is substantiated by the data which form the basis of Figures 1 and 2. There is an increase in frequency during the night of 14 per cent over that of the day, and an increase in total amount during the night of 23 per cent above that of the day. It is interesting to note that not only are the total hourly amounts of rain for the early morning hours greater, as would be expected with a greater frequency, but the increase in amount greatly exceeds the increase in frequency. The greatest frequency is 47 per cent more than the least frequency while the greatest amount of rain is 91 per cent more than the least amount.

In studying Figure 1, as a possible aid in forecasting, it is found that the forecast period 5 p. m. to 5 a. m. shows greater frequency of rainfall than the period 5 a. m. to 5 p. m., but probably this difference is not sufficient to be of any material help in forecasting.

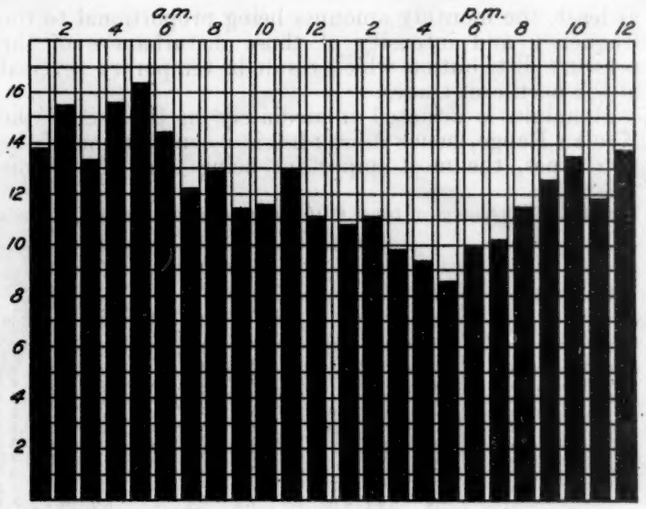


FIG. 2.—The total rainfall in inches for each hour of the day at Los Angeles, Calif., 1905 to 1913, inclusive

The results obtained by tabulating these data show that the greatest frequency of rainfall at Los Angeles is between 4 and 5 a. m. This is also true of the greatest amount. The least frequency is from 12 noon to 1 p. m. and also 4 to 5 p. m., and the least amount occurs between 4 and 5 p. m.

In considering these figures it must be remembered that this is a region of very light rainfall, the average annual amount being only 15.37 inches, so that a single excessive rain occurring in a given hour might bring the total of that hour considerably higher than that of the preceding and following hours. It would probably require a study of a period covering a great many years to smooth out the irregularities entirely.

DIURNAL VARIATIONS OF PRECIPITATION AT HONOLULU, HAWAII

By ELMER H. LOVERIDGE

[U. S. Weather Bureau, Honolulu]

Despite the fact that the greater portion of the rainfall of the Hawaiian Islands is caused by the ascent of the northeast trade winds over the mountains, there are large areas where this type of rain rarely occurs. Such areas are the lowlands a considerable distance to the leeward of the mountains. They show a marked minimum of rainfall in the summer months and early autumn, and a maximum in the winter and early spring for Oahu at least, the monthly amounts being proportional to the frequency and intensity of those disturbances of the pressure distribution which result in temporary reversal of the northeast trades.

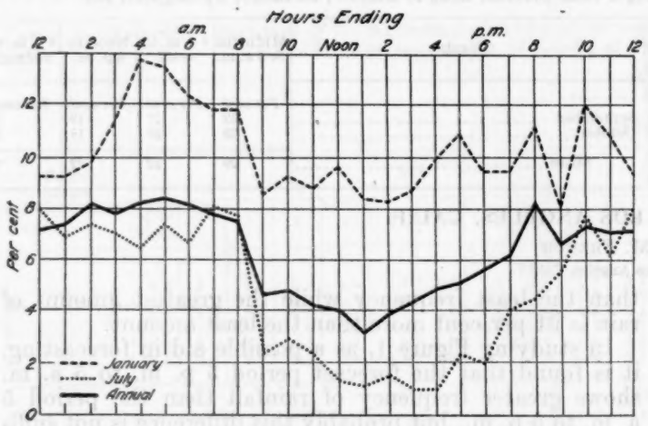


FIG. 1.—Average hourly frequency of rainfall for Honolulu, Hawaii, for the years 1905–1923, inclusive

Honolulu is situated immediately in the lee of the Koolau Range, hence its rainfall is a combination of the two types, the most important being that of cyclonic origin. The rains induced by the trade winds come in brief, light showers through which the sun not infrequently shines; hence the common local expression "liquid sunshine." It is probable that the condition most favorable to the formation of these showers is a more than usual amount of low cumulus or stratocumulus clouds over the surrounding ocean areas, together with a moderate wind force.

It is a matter of common observation that these showers, wherever they occur in the islands, are of most frequent occurrence during the night and early morning hours, a fact fortunate in its economic aspect in that it provides the maximum time for work in the cane fields.

Figure 1 shows the frequency curve for the months of January and July and for the year at the Honolulu Weather Bureau office, and Table 1 the same for each month of the year. On the average the time of day in which rain is most frequent is from midnight to 8 a. m.; thereafter there is a sudden drop. The diurnal drop varies much from month to month both in regard to time of maximum frequency and to the range between highest and lowest frequency. The length of record is, of course, not sufficiently long to give a curve for each month which approaches the true normal, but it is plain enough that the daytime drop in frequency is most pronounced in summer, and it is highly probable that the time and degree of maximum in the true normal curve for each month varies considerably.

The month of greatest range of frequency, as shown in the table, is July, when rain falls eight times as often in the hour ending 7 a. m. as in the hours ending 3 and 4 o'clock in the afternoon. On the other hand, in January the hour of greatest frequency is less than twice as rainy as the hour of least frequency.

TABLE 1.—*Percentage of times 0.01 inch or more of rain has fallen during each hour for the years 1905 to 1923, inclusive, at Honolulu, Hawaii*

Month	A. M.												P. M.											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
January	9.3	9.8	11.4	13.8	13.6	12.6	11.9	11.9	8.7	9.3	9.0	9.7	8.5	8.3	8.8	10.0	10.9	9.5	9.5	11.2	8.1	11.9	11.0	9.3
February	8.0	8.0	6.7	6.5	6.1	6.1	5.0	5.8	3.7	4.5	3.4	3.9	4.5	5.2	4.3	5.6	5.6	6.3	4.5	7.6	6.3	7.1	7.5	7.8
March	7.5	8.0	10.4	9.0	11.0	8.7	9.2	10.4	7.0	6.3	4.6	4.8	3.7	5.8	6.8	7.5	6.8	7.1	8.8	10.4	8.5	7.0	7.1	7.3
April	8.2	10.2	7.0	7.9	8.6	9.3	7.2	5.4	4.6	5.8	5.3	4.2	2.3	2.1	3.7	4.7	5.4	5.8	6.1	8.9	4.9	4.0	6.7	7.9
May	5.8	5.8	6.5	7.3	6.8	6.0	6.2	6.8	3.4	2.1	2.4	1.9	2.2	2.5	2.9	2.7	3.4	3.8	4.2	5.6	4.0	4.4	4.2	5.4
June	4.7	6.0	6.1	7.7	6.0	7.7	6.7	5.4	2.1	3.2	2.8	2.1	1.8	2.3	2.1	3.6	2.8	3.2	4.2	4.4	4.2	4.7	4.9	5.2
July	7.0	7.3	7.1	6.3	7.5	6.6	8.1	7.8	2.5	3.0	2.4	1.4	1.2	1.5	1.0	1.0	2.4	2.0	4.1	4.6	5.6	7.8	6.1	8.0
August	7.1	6.6	7.1	6.8	5.6	6.6	6.8	7.0	3.2	2.5	1.9	2.2	1.5	1.7	2.1	3.4	3.9	3.2	3.8	7.5	7.0	7.0	7.6	6.6
September	6.5	8.9	7.2	7.2	7.7	7.4	7.6	6.5	3.6	4.2	3.6	3.7	2.8	2.6	3.0	3.9	3.2	4.6	6.8	9.2	6.3	6.5	4.7	5.6
October	6.8	7.3	5.8	7.0	7.3	7.8	7.1	7.0	4.2	3.1	3.2	2.5	1.7	2.4	4.9	4.2	4.2	6.1	5.4	7.8	5.9	7.3	6.6	5.3
November	9.2	10.0	9.6	8.6	10.0	8.2	9.3	8.1	5.8	4.9	4.6	4.9	4.4	5.1	5.4	5.2	5.8	7.4	8.2	12.1	9.2	9.6	8.6	9.2
December	8.7	9.0	9.5	10.5	11.0	11.0	10.2	9.7	7.1	8.8	6.8	6.6	6.8	7.5	9.2	7.6	7.8	9.3	10.5	11.9	9.9	10.0	9.9	8.7
Means	7.4	8.1	7.9	8.2	8.4	8.2	7.9	7.6	4.7	4.8	4.2	4.0	3.4	3.9	4.5	5.0	5.2	5.7	6.3	8.4	6.7	7.3	7.1	7.2

In Table 2 is shown the frequency of day and night rains, and in Table 3 are given the percentages of rain which fall during the night for each month and for the year. The heavy falls which may occur on any one day, especially during winter, give rise to a high monthly variability and causes the figures as given in percentage of total rainfall to depart greatly from what would be the true normal. Thus in January the low percentage of 48 for the rain which falls at night was brought about by several heavy rains which fell during the daytime. The same is true with the still lower percentage in June. Averaging up the percentages for the summer half year and the winter half year we find that 62 per cent of the rain frequency and 61 per cent of the total rainfall occurs at night in the former, while 56 per cent of the frequency and 58 per cent of the total rainfall occurs in the latter. It is highly probable, therefore, that the diurnal variation in total rainfall is practically the same as for frequency.

FIG. 1.—Glaze storm, Springfield, Ill., December 17–18, 1924. (H. E. Neef, photographer)

(To face p. 584)

FIG. 1.—Glaze storm, Springfield, Ill., December 17–18, 1924. (H. E. Neef, photographer)

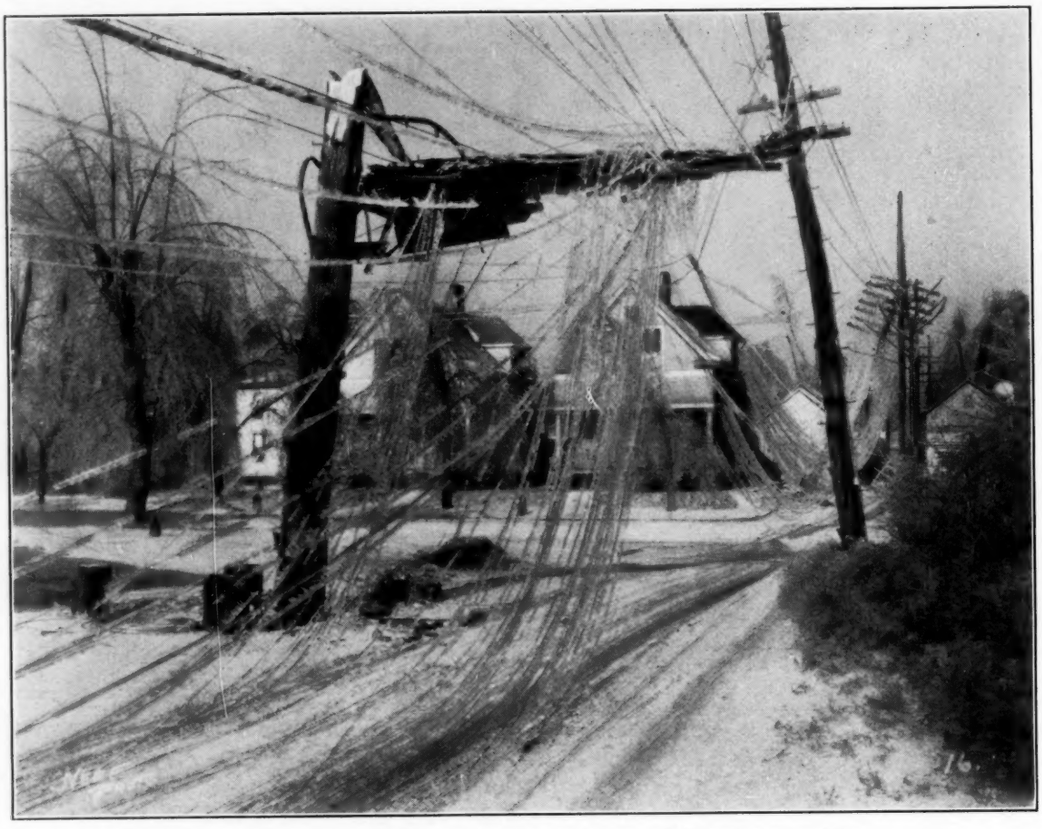


FIG. 2.—Glaze storm, Springfield, Ill., December 17–18, 1924. (H. E. Neef, photographer)

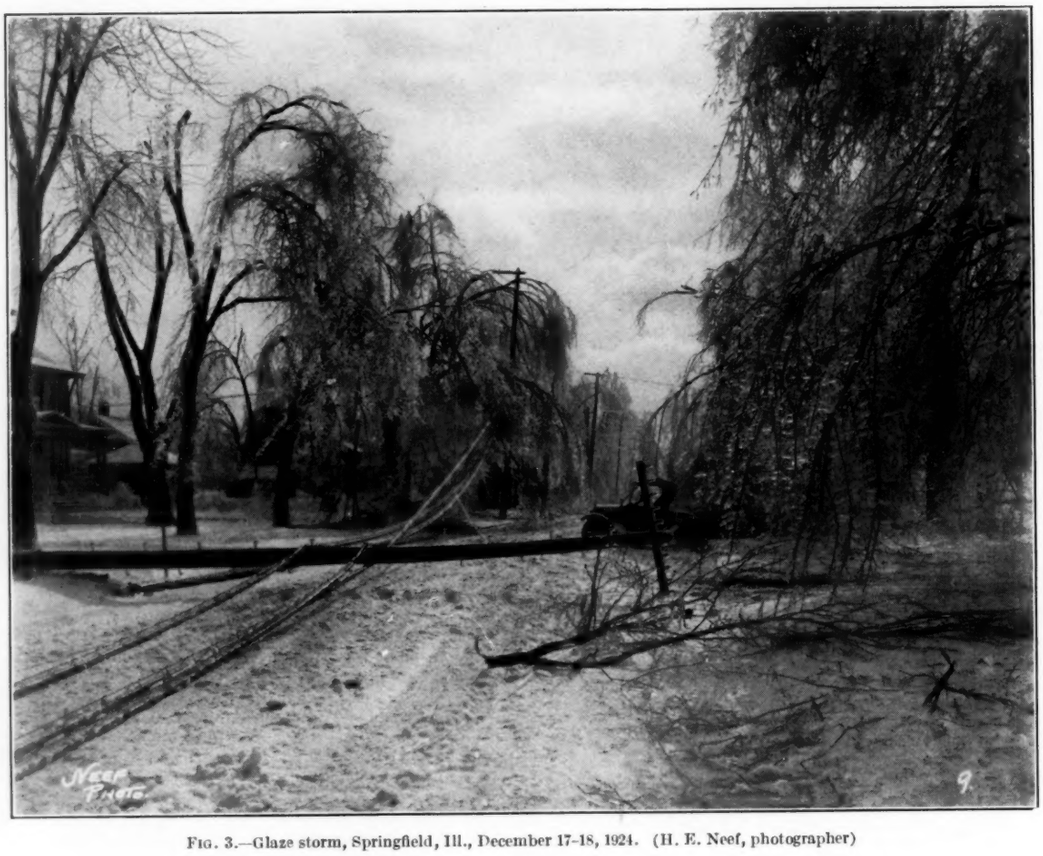


FIG. 3.—Glaze storm, Springfield, Ill., December 17–18, 1924. (H. E. Neef, photographer)

TABLE 2.—*Average number of times 0.01 inch, or more, of rain has fallen during the 12 hours ending with the 8 a. m. and 8 p. m. observations, for the years 1905 to 1923, inclusive, at Honolulu, Hawaii*

Month	8 a. m.	8 p. m.	Month	8 a. m.	8 p. m.
January	12	10	August	9	6
February	8	6	September	10	7
March	10	8	October	10	7
April	9	7	November	10	8
May	8	5	December	12	9
June	9	5			
July	11	4	Mean	10	7

TABLE 3.—*Percentage of rain falling during the nighttime (12 hours ending at 8 a. m.), for the years 1905 to 1923, inclusive, at Honolulu, Hawaii*

Month	Per cent	Month	Per cent
January	48	August	71
February	62	September	53
March	56	October	63
April	60	November	62
May	62	December	54
June	43		
July	78	Mean	59

The diurnal march of rainfall for Honolulu would normally be expected to follow the ocean type, the land masses being insufficient to induce any marked departure. It closely resembles that shown by Fassig [1] for San Juan, P. R., except for the absence of a small maximum during the early afternoon. The cause of the night maximum of cloudiness and rainfall is generally believed by meteorologists to be the result of a more rapid radiation aloft than at the ocean surface, thereby causing a convectional overturning of the air at this time. This being the case it would normally be expected that the diurnal variation would be the greatest at the equator, decreasing with increasing latitude in so far as this affects the intensity of insolation. The variation should also be greater in summer than in winter.

The unusual high night maximum in Honolulu during the summer time is probably caused by the more abundant formation of low clouds during the night hours, being just sufficient to form a shower over the city. It is worth remarking in this connection that the diurnal march of rainfall is generally opposite in this case to that of wind velocity, despite the fact that some wind is necessary to the formation of the trade wind shower.

A rather peculiar feature of the annual curve is the brief but marked secondary maximum between the hours of 7 and 8 o'clock in the evening. This secondary maximum can be observed in every month but July, and is very pronounced in the months of March, April, September, November, and December. In the last two months this secondary maximum is greater than the early morning one, though also briefer. It certainly is not synchronous with any known maximum of rainfall or cloudiness over the ocean.

[1] Cf. Fassig, O. L. Tropical rains—their duration, frequency, and intensity. Proc. Second Pan Amer. Scien. Cong.: 460–473.

THE GLAZE STORM OF DECEMBER 17-18, 1924, IN ILLINOIS [1]

By CLARENCE J. ROOT, Meteorologist

[Weather Bureau, Springfield, Ill., January, 1925]

A severe glaze storm occurred in west-central Illinois on December 17 and 18, the area of great destruction embracing a territory about 75 miles in width and 170 miles in length. During the entire period of the storm, warm and dry weather prevailed in the extreme southern portion of the State.

In the affected area trees were badly damaged, wires broken, and thousands of electric poles went down. Electric services were paralyzed, and it will require weeks to restore operation and months to permanently rebuild the lines. Some rural telephone systems were ruined. Fortunately, there was no wind; otherwise the destruction would have been much greater. The ground was covered with a crust of one or more inches of ice and sleet, and apprehension was felt for winter grains. The icy conditions, together with the cold weather that followed the storm, rendered difficult the work of restoration. There was no thawing until the 30th and none of consequence until January 3. The ice on the trees gradually decreased, but the ground conditions remained unchanged until the thaw.

The situation in Springfield was typical of the rest of the area. Sleet and freezing rain alternated, the total precipitation being 3.63 inches. Probably three-fourths of the trees in the city were injured to a greater or less extent, and in places the streets were a tangle of wires, poles, and brush. The ice on the upper side of objects ranged from 0.4 to 0.8 inch, and the weight of twigs was increased fifteen times. The depth of sleet and ice on the ground was 1.9 inches. It is probable that there was more ice in the storm of February, 1883, the weight of ice per foot of wire at that time being 11 ounces as compared with 8 ounces in the present storm. It must be remembered, however, that in 1883 there were very few wire services, so the money loss is far greater in the present storm.

The street railway company and the Illinois Traction System (electric) resumed complete operation 17 days after the storm. About one-half of the light and power customers had no electricity, and 3,000 telephones were out of commission. Electric light service was completely restored January 10. Springfield had no outside wire connection for several days. Without dispatching facilities and with frozen switches and frogs, the steam roads operated with great difficulty and trains were hours late. The ice had practically disappeared from the trees and wires by January 4, but at this writing, January 20, there is still considerable ice on the ground. The duration of ice on the trees is probably without precedent in this section.

The Western Union Telegraph Co. lost 8,000 poles and the Illinois Bell Telephone Co. about 23,000. The total damage to wire services in Illinois will probably equal or exceed $5,000,000. If there is added to this the loss of business, the damage to shade and orchard trees, and the possible injury to winter grains, the storm may be classed as one of the most disastrous of its kind in the history of the State.

[1] Condensed from the December number of Climatological Data, Illinois Section.

SLEET AND ICE STORM AT CORPUS CHRISTI, TEX., DECEMBER 19–21 AND 25, 1924 [1]

By J. P. McAULIFFE

A sleet and ice storm of great severity, for this region, occurred at Corpus Christi, Tex., December 19, 20, and 21, 1924, and a much lighter fall was recorded on the 25th.[2]

More sleet fell in the severe sleet storm of 1897, but owing to the sparsely settled country at that time, less damage was sustained than in the present storm.

Rain began about 2.10 a. m. of the 19th; at noon the surface temperature sank to freezing, and within half an hour thereafter overhead wires, trees, shrubbery, streets, and sidewalks were covered with a heavy coating of glaze making travel of all sorts difficult and dangerous. The coating on the wires and trees soon became so heavy as to cause the wires to break and branches of trees to collapse, while small ornamental trees and shrubbery were crushed to the ground. In rural districts the burden of ice caused telephonic communication to cease about 3 a. m. of the 19th, but it was not interrupted in the city until later in the day.

The storm persisted intermittently from the 19th to the 21st, during which time 0.3 inch snow and 0.9 inch sleet fell practically all of which remained on the ground. On the morning of the 21st there was an inch of snow and sleet on the ground, a rare occurrence for Corpus Christi.

[1] Condensed from the original.—ED.

[2] This sleet storm was rather general in southwestern Texas on December 19–20. It was due to the same meteorological conditions that produced the Missouri-Illinois storm described in the immediately preceding note.—ED.

THE SQUALL CLOUD IN A THUNDERSTORM; A DIRECT OBSERVATION OF ITS MOTION.

By DAVID L. WEBSTER

[Stanford University, Palo Alto, Calif., January 13, 1925]

In the very interesting discussion of thunderstorms given by Dr. W. J. Humphreys in his "Physics of the Air," the explanation of the squall cloud, or roll scud, is especially significant because that cloud is often so different in appearance from the main mass of cumulus clouds above it, and because its explanation as a result of interaction between the upward and downward currents is such a neat confirmation of the general theory. Because of these facts, direct observations of the motion in such a cloud are of some interest. As Doctor Humphreys informs me that records of such observations are quite rare, and I happen to have had an exceptional opportunity to make one, I venture to contribute this note in confirmation of the theory.

The occasion for this observation was a cross-country flight in October, 1918, in which Professor, then Major, C. E. Mendenhall and I were over the lower Rappahannock River, Va., in a Curtis JN4H, a small but fairly powerful plane, just as a thunderstorm was getting well started. Having read Doctor Humphreys' description, and seeing a well-developed roll scud under the forward side of this storm, I decided to investigate more closely.

I had had some previous experience with the saw-tooth shaped points that often appear on the tops of fracto-cumuli subject to overrunning winds, and had noted in them eddies with horizontal axes, that could roll an airplane flying through them remarkably suddenly. In fact, since there is plenty of room in which to recover equilibrium, such clouds make interesting opportunities for a form of safe and sane acrobatics different from those possible in still air. It appeared reasonable, therefore, to expect to confirm Doctor Humphreys' statement as to the probable rolling motions in the roll scuds, by flying into it at a small angle, so as to be headed almost along its axis, and seeing whether the airplane would likewise roll with it.

This expectation was not only confirmed, but confirmed to such an unexpected extent that the strain on the wings caused them to creak with a scream audible even through the roar of the motor. I promptly brought the machine up into a stall, to reduce the strain by reducing the airspeed, and dropped out of the cloud rolling with all the angular velocity that the most ardent upholder of this theory of thunderstorms could wish for.

The conclusion is that the theory is confirmed, as far as such an observation can confirm it, but that the experiment shares one characteristic with the famous thunderstorm experiment of Benjamin Franklin, namely, that its repetition is most decidedly inadvisable.

TEMPERATURE OF DEEP WATER

By W. J. HUMPHREYS

Obviously the temperature of deep water in any given case depends on the supply of heat in the body of water concerned at some previous time, and its subsequent gain and loss of heat. This gain by subsurface water is through conduction from the earth beneath, conduction from the warmer water above, absorption of residual insolation, exothermic, including biological, reactions, and forced convection due to currents and wave agitation. Conduction from the earth is negligibly small, save where the shore effects are relatively large, as in the case of a mere pond. Conduction from above to any considerable depth also is very slow, and the residual insolation energy beyond a few meters extremely small. The heat from animal metabolism and other reactions also clearly is negligible. There remains, then, only forced convection to carry any considerable amount of heat at all far and rapidly below the surface. This too, while exceedingly effective through the first 20 meters or so in the case of medium and larger sized lakes and all other bodies of water of similar area, does not extend to great depths. In fact, owing to forced convection, the temperature of the water is practically the same to 20 meters, more or less, below the surface, and there abruptly changes. Below this discontinuity layer, temperature decreases more and more slowly with depth, and presently becomes substantially constant, however great the remaining depth. This deeper water, then, gets only a negligible amount of heat by conduction, insolation, or convection. That is, it is enclosed by thermally all but impervious walls.

On the other hand, the loss of heat by the deeper water can occur only through conduction, radiation, and the addition of still colder water. Loss of heat by conduction clearly can occur only when the upper, and

therefore lighter, water is the colder, hence only when the surface temperature is below that of maximum density. This loss is quite negligible from water at any appreciable depth. Loss of heat by radiation from deep water also is of no consequence. There is left, then, only the advection of still colder water as a possible means of decreasing the temperature of the lower portions of any body of deep water. Hence:

a. In all bodies of water that annually, or even occasionally, are ice covered over any considerable portion of their extent, the temperature, from the greatest depth to within a few hundred meters (often much less) of the surface should, it would seem, be practically constant, and that of maximum density.

And this, indeed, is the deep temperature of all oceans and of the various suitable lakes that have been explored.

b. If no portion of the water ever freezes or cools to the temperature of maximum density, that is, if the body of water be a deep lake in tropical or subtropical regions, we should expect, as before, constancy in the temperature of the deeper portions; not, however, the temperature of maximum density but that of the coldest portion of the surface wherever and whenever (barring rare and freakish extremes) that should occur.

Observational checks of this conclusion unfortunately are not at hand except in respect to Lake Tanganyika in Central Africa, Lake Atitlan in Central America, and the Red Sea. The first of these gives an excellent check since it lies nearly north and south, is over 400 miles long, and very deep—at least 1,277 meters. According to numerous observations and many soundings,[1] the surface temperature ranges from 26.3° C. at the end nearest the Equator to 23.3° C. at the opposite end, while that of the body of the water decreases from the average of 25.0° C. at the surface to the continuous temperatures 23.2° C. at the depth of 200 meters, and 23.15° C. at and beyond the 400 meter level. That is, the constant temperature of the deeper water is practically the same as the minimum temperature of the coolest part of the surface.

Lake Atitlan, roughly 22 miles long, also supports this conclusion. On February 12, 1910, the temperatures of this lake[2] were, surface, 19.6° C. (a little warmer, no doubt, than in January), 50 meters below the surface, and down to the 315-meter bottom, 19.2° C.

The temperature data of the Red Sea likewise are applicable in this case since through practically its whole length of 1,200 miles it is much deeper, in places 2,000 to 2,190 meters deeper, than its 82-meter connection with the Indian Ocean. The great body of the water in this basin therefore below the 200-meter level, say, if once appreciably colder, as it now is, than the minimum shoal temperature in the strait of Bab-el-Mandeb, must so remain for a long while.

Now, from such data as I have found on the subject, chiefly that obtained by the "Pola" expeditions,[3] the minimum surface temperature of the northernmost, hence coolest, portion of the Red Sea, exclusive of the shallow Gulf of Suez, discussed below, is about 21.5° C., and the maximum, in the southernmost portion, about 32° C. At and below the 100-meter level the temperature throughout the sea is nearly constant and uniform, and below the 700 meter-level quite so at approximately 21.5° C. These values hold also for the deep Gulf of Akaba. The northern portion of the Red Sea is saltier also, owing to abundant evaporation and practical absence of inflow, as well as colder, than the southern. Hence, both because more saline and because colder, the northern portion of the sea must furnish the deeper water of the entire basin. Furthermore, since the distribution of salinity varies but little, the maximum density, the condition that determines inflow to the deeper portions, occurs at or near minimum temperature.

As implied above, the narrow Gulf of Suez, 172 miles long, but only about 50 meters deep, requires special consideration in this connection. Here the temperature of the water when coldest is only 17° C. to 18° C. and that, too, from top to bottom. During summer, on the other hand, this water is warm throughout. These conditions are owing to the fact that the depth of this gulf is not great enough, as is that of the Gulf of Akaba and the Red Sea proper, to take care of the winter surface cooling without affecting the temperature of the bottom water.

But why, one asks, does not this coldest water drain out into the basin of the sea? Doubtless some of it does and some also in the summer when, though warm, the salinity is abnormally high owing to excessive evaporation. The mingling of these two seasonal flows necessarily gives deep water of an intermediate temperature that can not differ much from 21.5°. But such of these flows as do exist clearly are comparatively small in amount and, apparently, of such nature that so far as thermal effects are concerned we may regard the Gulf of Suez as being no part at all of the Red Sea.

As nearly then as we can infer from the data available, the temperatures of the Red Sea likewise support the conclusion that deep-water temperatures of any sea or lake, when higher than that of maximum density, is determined by, and substantially the same as, the annual minimum temperature of the coolest portion of its surface.

Hence, if climate has long been constant, presumably the deep-water temperatures of all tropical and semi-tropical lakes can be closely approximated by observing over a sufficient period their minimum surface temperatures, not, in any given case, of the surface as a whole, but of that considerable portion that gets coldest. Also when, as in the case of Lake Tanganyika, the minimum surface temperature and the abysmal temperature are the same, we may infer that for decades at least, if not centuries, the local climate has not been appreciably colder than it now is. On the other hand, a marked difference between these temperatures would indicate a relatively modern change in the local climate to warmer than formerly if the bottom water is colder than the surface minimum, or, quite recently (too recent for adjustment) to colder if the temperature of the deep water is noticeably higher than the surface minimum.

[1] Marquardson. *Mitteilungen aus den Deutsch. Schutzgebieten*, 29, p. 97, 1916.
[2] Juday, *Trans. Wis. Acad.*, 18, p. 244, 1915.
[3] *Denkschrift*, K. K. Akad. Wiss. Vienna, v. 65, 1898, and v. 69, 1901.

THE WEATHER OF 1924

ALFRED J. HENRY

Temperature.—The abnormality of temperature for the year comes out as 0.6° F. below the normal (see Table 1). This result, however, is due to the low temperature of the last month of the year and of the last 10 days in that month. Had the computation ended with December 20 the final result would have been a positive departure of at least a whole degree Fahrenheit. No striking abnormalities appear in the figures of Table 1. In general the spring was cool and wet east of the Rocky Mountains, the summer was close to the normal, and the autumn on the whole was warm, relatively high temperature continuing well into December.

The geographic distribution of the temperature abnormalities are shown in Figure 1 and the monthly abnormalities in Table 1.

TABLE 1.—*Temperature departures, 1924*

Districts	January	February	March	April	May	June	July	August	September	October	November	December	Average monthly departure
New England	+3.0	−3.7	+1.7	−0.3	−2.1	−1.4	0.0	+0.5	−1.9	+0.3	+1.7	−2.5	−0.4
Middle Atlantic	+1.6	−1.8	+0.1	−1.1	−3.6	−1.4	−1.6	+0.1	−3.7	0.0	+0.5	−0.3	−0.9
South Atlantic	−1.3	−3.4	−2.8	−1.0	−1.9	+1.4	−1.0	+1.6	−2.7	−1.5	+1.2	+1.5	−0.8
Florida Peninsula	*												
	+1.6	−3.6	−4.2	+1.4	−0.1	+1.3	+0.6	+1.5	+0.4	−1.2	−0.4	+4.1	+0.1
East Gulf	−4.3	−2.3	−4.4	−0.5	−3.3	+1.6	−0.1	+2.8	−2.2	0.0	+2.3	+1.0	−0.8
West Gulf	−3.6	−0.6	−5.0	−0.2	−3.7	+1.8	−0.7	+2.9	−1.5	+2.3	+4.2	−2.1	−0.5
Ohio Valley and Tennessee	−3.8	−1.6	−4.2	+0.1	−6.2	−0.1	−2.7	+0.8	−4.6	+2.8	+0.8	−2.3	−1.8
Lower Lakes	−1.2	−2.9	−0.6	−1.2	−6.3	−2.6	−2.5	−0.3	−4.0	+1.9	+0.6	−4.3	−2.0
Upper Lakes	−5.0	+1.6	+1.1	−0.3	−5.0	−2.6	−3.1	−1.4	−4.3	+5.0	+0.4	−7.2	−1.7
North Dakota	−1.6	+12.9	+4.1	−1.0	−6.5	−3.4	−1.9	−1.3	−1.3	+8.2	+1.4	−9.1	0.0
Upper Mississippi Valley	−4.6	+2.9	−2.2	+1.5	−6.7	−2.3	−3.7	−0.5	−5.1	+6.3	+1.7	−7.4	−1.7
Missouri Valley	−4.0	+4.7	−3.8	+1.4	−5.9	−1.7	−3.3	+1.1	−3.9	+6.6	+3.2	−8.1	−1.1
Northern Slope	−2.7	+8.6	−4.4	−0.8	−1.4	−1.7	−0.1	−0.2	−1.1	+3.2	+1.4	−10.3	−0.8
Middle Slope	−2.4	+3.7	−8.6	−0.3	−5.0	+2.2	−1.7	+2.4	−2.8	+4.2	+3.7	−7.8	−1.0
Southern Slope	−1.8	+0.6	−4.8	−1.3	−3.8	+3.7	−1.0	+3.0	−1.6	+1.2	+4.1	−3.7	−0.4
Southern Plateau	−1.2	+3.9	−4.7	−1.3	+2.5	+3.7	−0.1	+1.3	+1.8	+0.2	+2.2	−2.2	+0.5
Middle Plateau	−4.6	+6.8	−5.0	+0.1	+4.9	+3.1	+1.4	+0.2	+0.1	−0.6	−0.1	−7.6	−0.1
Northern Plateau	−3.0	+8.5	−2.0	−0.2	+6.2	+1.4	+1.5	−0.2	+1.4	+1.4	−0.9	−8.6	+0.5
North Pacific	+0.9	+5.0	−0.4	+0.5	+2.7	+0.7	+0.3	−0.2	+0.5	+1.0	−0.4	−4.7	+0.5
Middle Pacific	0.0	+4.3	−0.9	+2.0	+3.1	+0.9	−0.7	−0.7	+0.5	−2.2	−0.3	−3.9	+0.2
South Pacific	+1.6	+5.6	−0.9	+1.1	+3.5	+1.4	−1.2	−1.7	+0.4	−2.6	+1.5	−1.2	+0.6
United States	−1.7	+2.3	−2.5	−0.7	−1.8	+0.3	−1.0	+0.6	−1.7	+1.7	+1.4	−4.1	−0.6

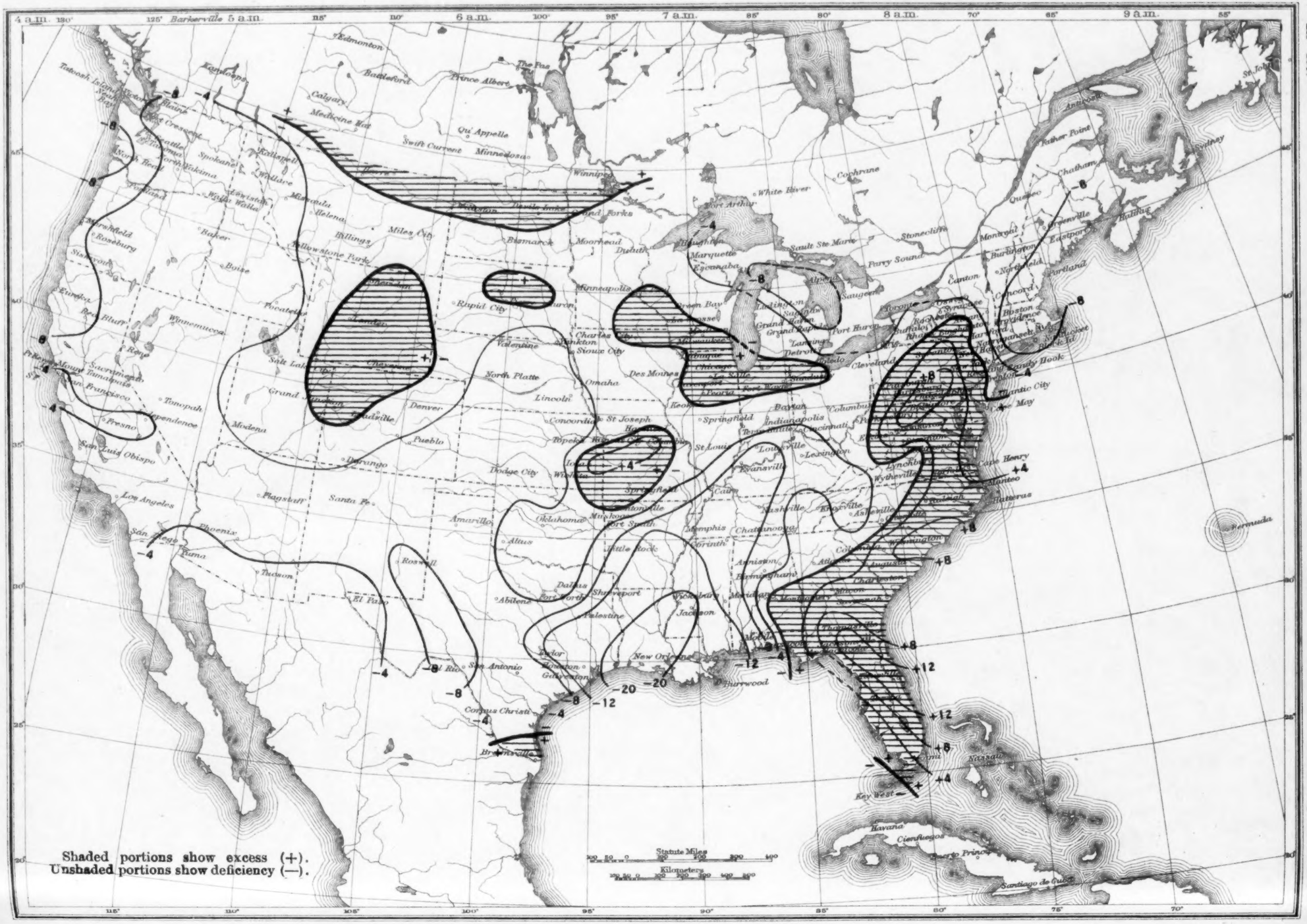
Precipitation.—Notwithstanding the wet weather in Atlantic Coast States in April, May, and September, the year as a whole for the entire area was a dry one. The greatest deficit in rain was felt from the Rocky Mountains to the Pacific, also in a somewhat less degree in the Plains and Gulf States. Figure 2 shows the geographic distribution of the abnormalities and the monthly amounts are given in Table 2.

TABLE 2.—*Precipitation departures, 1924*

Districts	January	February	March	April	May	June	July	August	September	October	November	December	Accumulated departure for year
New England	+0.1	−1.0	−2.4	+1.7	−0.1	−1.0	−1.8	+0.6	+1.5	−3.4	−1.6	−1.5	−8.9
Middle Atlantic	+0.3	−0.2	−0.5	+1.5	+1.7	+0.8	−1.5	0.0	+2.7	−2.8	−1.0	−0.7	+0.3
South Atlantic	+0.2	−0.8	−0.7	+1.1	−0.6	+0.4	+1.8	−2.4	+6.8	−1.7	−1.5	+0.7	+3.3
Florida Peninsula	+0.1	−0.6	+0.6	−0.4	+0.8	−1.3	+0.9	−3.0	−0.9	+8.5	−1.9	−1.5	+1.3
East Gulf	+1.2	−0.4	−2.9	+1.2	−0.1	+0.7	−1.7	−2.4	+1.8	−2.3	−3.2	+2.2	−5.9
West Gulf	−0.3	0.0	−0.5	−0.2	+0.6	−0.4	−2.6	−1.6	−0.8	−2.5	−2.1	−0.3	−10.7
Ohio Valley and Tennessee	+0.6	−1.1	−0.9	+0.4	+1.0	+0.3	−1.2	−1.2	+1.6	−2.3	−2.0	+1.0	−3.8
Lower Lakes	+0.2	−0.4	−1.1	+0.9	0.0	+0.3	−0.3	−0.8	+2.8	−2.6	−1.7	−0.1	−2.8
Upper Lakes	−0.2	−0.2	−0.5	−0.1	−0.2	−0.3	+0.2	+1.3	−0.6	−2.3	−0.8	−0.4	−4.1
North Dakota	−0.4	−0.2	−0.5	+1.2	−1.6	+1.5	−1.4	−0.2	+1.0	+0.9	−0.5	−0.1	−0.3
Upper Mississippi Valley	−0.6	−0.6	+0.2	−0.9	−1.7	+2.1	−0.5	+2.6	−0.5	−1.3	−1.0	+0.6	−1.6
Missouri Valley	−0.4	0.0	0.0	−1.4	−1.9	+1.6	−0.1	+0.4	+0.4	−0.6	−0.4	+1.2	−1.2
Northern Slope	−0.4	−0.2	+0.3	−0.8	−0.7	−0.2	−0.4	−0.5	0.0	+0.5	−0.1	+0.5	−2.0
Middle Slope	−0.3	−0.4	+0.9	+0.1	−1.8	−1.9	−0.4	−0.7	−0.4	−0.6	−0.2	+0.6	−5.1
Southern Slope	−0.5	+0.2	+0.2	−0.4	−0.9	−1.6	−0.6	−1.0	−0.2	−1.1	−0.8	−0.2	−6.9
Southern Plateau	−0.6	−0.6	+0.1	0.0	−0.2	−0.3	−0.3	−0.4	−0.7	−0.4	−0.5	+0.3	−3.6
Middle Plateau	−0.8	−0.7	+0.3	−0.5	−0.4	−0.4	−0.1	−0.5	−0.4	+0.3	−0.2	+0.8	−2.6
Northern Plateau	−0.9	−0.1	−1.0	−1.0	−1.6	−0.6	+0.2	+0.2	−0.2	0.0	+0.3	0.0	−4.7
North Pacific	−2.3	+0.9	−3.0	−1.7	−2.0	−1.1	−0.3	+0.2	+0.6	+3.2	−0.7	−0.6	−6.8
Middle Pacific	−2.2	−1.9	−2.2	−1.8	−1.2	−0.4	0.0	+0.2	−0.5	+2.1	−0.6	−0.3	−8.8
South Pacific	−2.2	−2.4	+0.6	−0.3	−0.6	−0.1	0.0	0.0	−0.2	−0.2	−0.4	−0.6	−6.4
United States	−0.4	−0.5	−0.6	−0.1	−0.5	−0.1	−0.5	−0.4	+0.7	−0.4	−1.0	+0.1	−3.7

A. J. H. I. Annual Temperature Departures (°F.) in the United States, 1924

II. Annual Precipitation Departures (inches) in the United States, 1924



TROPICAL DISTURBANCES DURING THE HURRICANE SEASON OF 1924

By W. P. DAY

During the hurricane season of 1924, there were eight disturbances near or within the Tropics, which were potentially dangerous or actually reached hurricane intensity. Three of these caused full hurricane velocities over some portions of their paths, two gave strong gales to near hurricane winds, and the remaining three failed to develop more than moderate intensity.

The first disturbance, which was followed from the 18th to the 20th of June from the northwestern Caribbean to the southwestern Gulf of Mexico, caused heavy rains but apparently no high winds.

Following this disturbance, nothing of importance was noted until August 17, when a disturbance of slight intensity appeared over the Lesser Antilles. It moved northwest, reaching the Virgin Islands on the 19th without any increase in intensity. It was accompanied by heavy rain but no damaging winds. It was next noted as it turned the winds around at Turks Island, the storm passing to the north of the station. By the 21st, however, there had been considerable development, one vessel reporting a wind force of 11 (Beaufort) and 29.52 inches on the barometer. Up to this time the course of the storm had been toward the northwest, but an obstructing high-pressure area now deflected it toward the west-southwest and it did not start north again until the night of the 24th, meanwhile developing the greatest intensity just north of the Bahamas with hurricane velocities and barometer readings as low as 28.70 inches. On the 25th the storm began to move very rapidly north-northeast and at noon was very accurately located by three vessels near latitude 32° N. and longitude 76° 30′ W., the ships reporting barometer readings of from 28.76 to 28.80 inches. At 8 p. m. it was just southeast of Hatteras, a vessel reporting 28.67 inches. It reached Nantucket shortly after noon of the 26th and was last noted near Port Aux Basques, Newfoundland, the next morning. The path of this storm was quite unusual and shows the effect of the extratropical circulation upon the movement of these storms. After the storm was well out of the Tropics the heaviest winds were experienced on the southeast quadrant (on the side toward the HIGH), and little damage resulted to the west, except near the storm center.

This hurricane had barely receded from the limits of observation before a new one, already of maximum intensity though small diameter, made its appearance between Antigua and Guadeloupe of the Lesser Antilles on the night of the 27th of August. The center passed over Cudjoc Head, Montserrat at 3.30 a. m. of the 28th with readings on nearby barometers as low as 28.50 inches. The center was again exactly located as it passed over the western end of Tortola of the Virgin group. The lowest reading at this point was 28.56 inches at 1.30 a. m. of the 29th. From this time until the storm reached Newfoundland on the 4th of September it was encountered by various vessels, but none reported the extreme conditions of wind and low barometer which were recorded over the Lesser Antilles. The islands in the direct path of the center of the hurricane were almost completely devastated by wind and by flood waters from the extremely heavy rainfall.

On the morning of the 13th of September a disturbance was noted in the central portion of the Gulf of Mexico. This developed and moved, at first, slowly northwest, but was caught in a passing trough of low pressure and turned sharply toward the northeast, striking the northwest Florida coast near Appalachicola on the 15th and moved thence up the Atlantic coast with diminished intensity. Near hurricane velocities were recorded here and reported from the vicinity, but little damage resulted. Like the preceding storm the area covered was quite small but the intensity was much less on account of the higher minimum reading of the barometer near the center (29.12).

The next disturbance was noted on the morning of the 27th of September in the vicinity of the Swan Islands. It had a well-defined circulation, but did not develop the central core of low barometer which was so well shown in the two preceding storms. Consequently dangerous winds were absent. It reached the Florida coast near Cedar Keys during the afternoon of the 29th and continued up the Atlantic coast as a storm of only moderate intensity.

On the 12th of October a well-defined disturbance developed over the north-central Gulf of Mexico, but was forced southwestward and apparently dissipated over the southwestern Gulf on the 14th.

At the same time the air pressure began to fall in the vicinity of the Swan Islands. This new disturbance remained nearly stationary until about the 18th by unfavorable pressure distribution to the northward, but meanwhile it had developed greatly in intensity with a central pressure below 28 inches and hurricane winds. It began to move northward on the 18th and passed over the extreme western end of Cuba on the 19th, Los Arroyas reporting a pressure of 27.52 inches and the S. S. *Toledo* near Jutias Cay (northwest coast) 27.22 inches. The storm struck the Florida coast in the unsettled region south of Punta Rassa and quickly diminished in intensity, passing off into the Atlantic just north of Miami. The southward movement of a great HIGH caused the path of the storm to be deflected quite sharply to the eastward and apparently aided in its disintegration. Almost complete destruction was wrought over extreme western Cuba in the path of minimum barometer.

On the 8th of November a definite cyclonic circulation was noted over Jamaica, which moved slowly north across eastern Cuba on the 9th accompanied by gales. It then turned toward the northeast and was encountered by the U. S. S. *Concord* in the southeastern Bahamas as a storm of considerable intensity. It continued in a northeasterly direction, passing just southeast of Bermuda on the 13th and was last noted south of the Grand Banks on the 15th. (See Chart XV at end of this REVIEW.)

NOTES, ABSTRACTS, AND REVIEWS

AIR TEMPERATURE AND THE INTENSITY OF RADIO SIGNALS

As a part of the research program of the International Union of Scientific Radio Telegraphy, the Radio Physical Laboratory, Bureau of Standards, Washington, has been carrying out field intensity measurements on the Radio Corporation stations located at New Brunswick, N. J., and Tuckerton, N. J. The following extracts from a communication by Mr. L. W. Austin, in charge of this work, on behalf of the International Union, brings out clearly a relation between air temperature and the intensity of radio signals.

Measurements on stations at moderate distances were first taken up with the intention of using their signals as standards for the calibration of the telephone comparator employed in the measurement of European stations. During the preliminary experiments satisfactory constancy was obtained in the signals from WQK (Rocky Point), L. I., but as warm weather came on, irregularities appeared and the observations were shifted to WII (New Brunswick, N. J.) since it is nearer and for this reason perhaps less likely to show variations. Observations were taken twice a day at about 10 a. m. and 3 p. m. on a low antenna swung about three meters from the ground between the towers of the main antenna. The radiation height (effective height) is 1.2 meters. The mean of the morning observations for the year, omitting the disturbed days in January, February, and March, gives a field intensity for New Brunswick of 3.06 millivolts per meter. As 10 per cent is, under ordinary circumstances, the limit of accuracy of these measurements, observations which lie within this limit are considered normal.

In June, 1923, the morning signals from WII, which are more regular than those of the afternoon in summer, on account of the absence of the afternoon absorption, fell below normal on 10 days, on 3 of which the deviation lay between 30 per cent and 50 per cent. In July, the morning signals were abnormal on 7 days, twice being more than 30 per cent low, while on July 17 they rose for an hour or two to 85 per cent above normal without apparent cause.

From August 1 to December 30, 1923 the signals were more regular. During August they varied in the morning less than 10 per cent except for slight variations on three days. In September they were also below normal on 3 days, one day being 40 per cent low. In October they again exceeded the 10 per cent variation slightly on 3 days. In November the three variations were all high, the greatest deviation being 24 per cent. In December there was one low variation of 21 per cent and one high, 63 per cent.

Regular observations were begun on WGG, Tuckerton, in October, 1923. This station averages about 12 per cent below WII in intensity, giving 2.7 millivolts per meter. Table 1 shows the monthly averages of the New Brunswick (WII) and of the Tuckerton (WGG) observations for both morning and afternoon, and figure 1 shows the morning values in graphic form.

TABLE 1.—*Monthly average signal intensities (millivolts per meter) of stations WII and WGG, at 10 a. m. and 3 p. m., June, 1923, to May, 1924, measured at Bureau of Standards*

Month	New Brunswick (WII)		Tuckerton (WGG)	
	10 a. m.	3 p. m.	10 a. m.	3 p. m.
June	2.86	2.53		
July	2.94	2.62		
August	2.91	2.60		
September	2.91	2.96		
October	2.94	2.84	2.60	2.56
November	3.26	3.13	2.72	2.60
December	3.18	3.00	2.77	2.79
January	4.52	4.02	3.88	3.88
February	4.94	5.19	3.82	4.58
March	3.56	3.51	2.81	2.84
April	2.95	3.11	2.73	2.91
May	2.60	2.55	2.40	2.65

During December 1923, there was no very cold weather in Washington, but with the cold waves of January, 1924, there was a marked increase in the irregulatities of WII and WGG and in a lesser degree of WQK. This last station was only observed occasionally. At the time of the passage of each of the cold waves there was an increase in signal strength especially during the severe cold toward the end of the month. In order to show this more clearly the maximum signal of WII or WGG at the two observation times and the reciprocal of the temperature are plotted in Figure 2. The observations on the signals and the 8 o'clock a. m. temperatures at the Bureau of Standards are given in Table 2.

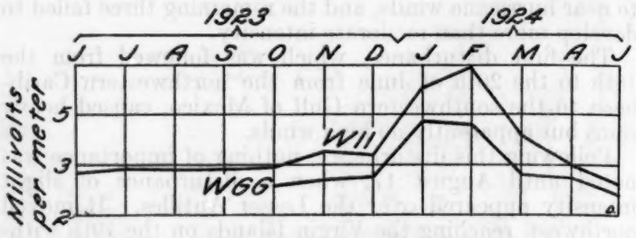


FIG. 1.—New Brunswick (WII) and Tuckerton (WGG) monthly average (a. m.) signal intensities at Bureau of Standards

TABLE 2.—*Signal intensities (millivolts per meter) of stations WGG and WII, and air temperature, measured at Bureau of Standards, January, 1924. Maximum intensities in italics*

Date	Tuckerton (WGG)		New Brunswick (WII)		Temperature (8 a. m.) at Bureau of Standards
	10 a. m.	3 p. m.	10 a. m.	3 p. m.	
					° F.
1					
2	*3.43*	2.56	2.66	2.33	29
3	2.70	2.56	*3.06*	2.66	36
4				*3.13*	27
5	2.63			*3.26*	31
6					
7			*5.00*	3.13	19
8	*5.66*	3.16		3.06	22
9			*3.26*		33
10			*3.13*	*3.13*	37
11	3.16			*3.19*	63
12		2.96	*3.26*		35
13					
14		*3.80*	3.66	3.06	26
15	2.96	*5.56*			21
16		2.96	*3.13*		40
17		3.73	*4.66*	3.33	41
18		4.93	5.66	*6.00*	35
19	3.93	2.96	*5.32*	3.26	33
20					
21	2.76	3.93		*6.65*	10
22	*5.56*		*6.00*	4.33	8
23	2.96	2.96	*3.26*	*3.26*	29
24	4.60	4.93	*5.00*	*5.00*	30
25	4.26	4.93	*5.00*		35
26	4.93	4.26	*5.66*	5.00	16
27			*6.65+*		12
28	4.93		*6.65+*	4.66	20
29	2.96	4.60	5.32	*6.00*	34
30	3.60	4.93	3.26	*5.33*	42
31	*4.93*	3.94		4.66	33

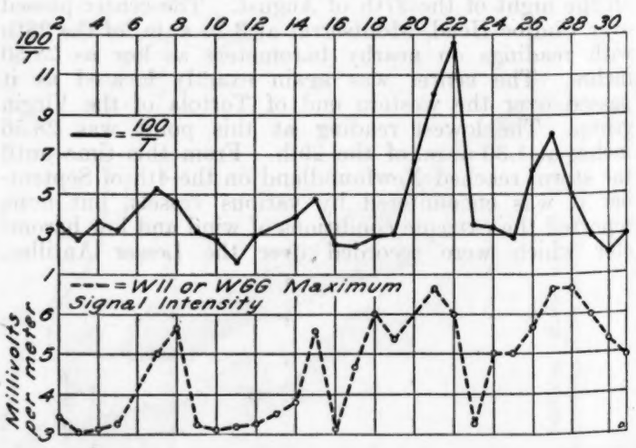


FIG. 2.—Signal intensity and temperature, January, 1924. The maximum intensity and the reciprocal of the temperature are shown

During the moderate cold of January 7 and 15, 1924, sometimes only one of the two stations seemed to be affected and the high readings were observed for only a part of the time, but during the extreme cold of January 22 and 27 both of the stations regularly observed as well as WQK and WSO (Marion, Mass.) remained high throughout the day, and in the last case for several days. There were also at these times marked shifts in the apparent directions of the stations even in the forenoon when their bearings are usually correct. NSS (Annapolis) 53 kilometers away, showed no increase in signal strength during these times. The end of the cold weather of January did not at once restore receiving conditions to the uniformity of the autumn and early winter but left an instability which persisted through the comparatively mild cold of February and a portion of March. During this time the signals from WII and WGG fluctuated frequently, going to more than twice their normal strength for a few hours and then returning to normal without any obvious relation to weather conditions.

Since March 19 these large irregularities have ceased and transmission seems to have returned to a stable condition with nearly the same average signal strength as in the autumn. The observations which have been taken on Annapolis and on the Radio Corporation stations at various distances indicate that large variations in intensity do not generally occur at 50 kilometers, that they are large at distances of 250 to 300 kilometers and again become less at 400 to 700 kilometers.

The few night observations which have been taken show somewhat higher and less regular values than those taken during the day.

It is too early to give any definite explanation of the variations observed. Their cause is evidently atmospheric and the connection with the cold waves of January suggests either that the part of the atmosphere concerned in the variations lies much below the Heaviside surface (80 or 100 km.) or that weather phenomena are in some way correlated with atmospheric action at much greater heights than has been hitherto supposed.

SERIOUS DROUGHT IN SOUTHERN HEMISPHERE

Information from various sources indicates the existence of a serious drought in various portions of the Southern Hemisphere.

In a recent communication from Señor Julio Buston Navarete of the El Salto Observatory of Santiago, Chili, he remarks as follows:

The present year (1924) has been extraordinarily dry in all parts of the Southern Hemiphere. Observations received from Australia, from all of America, and from South Africa indicate a deficiency of rain in all of these regions.

In Chili the rainfall of 1924 was the least in 100 years according to the journal El Diario Illustrado, Santiago, Chili, November 13, 1924.

Attempt has been made to discover the extent and precise location of this drought through the literature which is received in the Weather Bureau library. The result is that no information is available for Australia, except for Brisbane, only. For this place seven out of the nine months available for 1924 show a rain deficit of 11.42 inches; as an offset against this amount two months had an excess of 5.99 inches. The total deficit is therefore about 6 inches.

For Rhodesia, South Africa, the rainfall of the period, October, 1923–April, 1924, was but 60 per cent of normal—a severe drought.

For South America, in addition to Chili, as above, returns from Brazil indicate that the winter months of July and August, and the months of September and October were rather markedly deficient in rainfall. For Argentina, the returns bring the rainfall up to August, 1924, only. These, as in Brazil, show a deficit for the winter months rather more general than in Brazil, although not so pronounced as in Chili.

For the United States and Canada, the chart, page 589, shows the abnormalities of rainfall for 1924.—*A. J. H.*

JAMAICA RAINFALL IN 1923

The editor is in receipt of publication No. 564, Rainfall Statistics for Jamaica, 1923.

In common with other parts of the West Indian-Caribbean region and the northern coast of South America, the rainfall of 1923 in Jamaica was deficient by amounts ranging from 20 to 25 per cent of the 50-year normal. The year 1923 marks the third consecutive year with deficient rainfall centering in the West Indies.

The monthly and annual amounts for approximately 425 stations in this region are given in the publication Climatological Data, West Indies and Caribbean Service, issued at San Juan, P. R., Dr. O. L. Fassig, in charge.

RAINMAKER FAILS

Under the caption, "Rainmaker fails. Hatfield folds tower, silently leaves valley," the Fresno Bee, Fresno, Calif., in its issue of December 21, 1924, published the following:

BAKERSFIELD (KERN CO.), December 20.—Charles M. Hatfield, "rainmaker," is silently making preparations to leave La Panza Plains, this county, after failing by 0.6025 inches to fulfill his contract for producing 1½ inches of rain between November 20 and December 20. The effort was unsuccessfully terminated at midnight last night, according to Frank G. Munzer, timekeeper for the stockmen who put up the $4,000 which was to have been paid the "wizard." Official gauges at Maricops [Maricopa?], the Olcese ranch, Bakersfield, and Delano, registered 0.8975 inches, Munzer said.

OPEN WINTER IN BAFFIN BAY

In a recent letter to Rear Admiral Billard, commandant, Coast Guard, dated Detroit, Mich., Donald MacMillan, well-known Arctic explorer, makes the following interesting comments:

In my 16 years of Arctic work I have never seen Baffin Bay so clear of ice as last season (1924).

I attribute this to very strong, constant northerly winds throughout all last winter and spring and, consequently, expected a clear run home from latitude 78° 31′ N., which we had. We have had now two very good seasons in the far north, all waters being remarkably free of heavy ice.

Readers of the REVIEW will be interested to know that Mr. MacMillan plans to return to the Arctic region next summer.

BIBLIOGRAPHY

C. FITZHUGH TALMAN, Meteorologist in Charge of Library

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

RECENT ADDITIONS

Booth, Edgar H.
Atmospheric dust and atmospheric ionisation. p. 173–210. figs. plates. 23 cm. (Journ. & proc. Roy. soc. New South Wales. v. 57, 1923.)

Dorno, C
Zur Technik der Strahlungsmessungen. p. 177–184. diagr. 24½ cm. (Repr.: Strahlentherapie. Bd. 18, 1924.)

Hellmann, G.
Versuch einer Geschichte der Wettervorhersage im XVI. Jahrhundert. Berlin. 1924. 54 p. 27½ cm. (Abhandlungen preuss. Akad. der Wissensch. Jahrg. 1924. Phys.-math. Klasse. Nr. 1.)

Hoxmark, Guillermo.
La aviación y la meteorología. Buenos Aires. 1924. 13 p. figs. plate. 31½ cm. (Boletín meteorológico. 1920.)

Johnstone, James.
Introduction to oceanography, with special reference to geography and geophysics. London. 1923. xii, 351 p. illus. plates. diagrs. 22½ cm.

Marriott, William.
Hints to meteorological observers. Prepared under the direction of the council of the Royal meteorological society. 8th ed. London. 1924. 95 p. illus. 25 cm.

Melander, G.
Exposé des recherches météorologiques de Finlande. Helsinki. 1924. 13 p. 22 cm. (Préparé pour l'Institut international d'agriculture.)

Peppler, Wilhelm.
Die Temperaturverhältnisse von Baden. Karlsruhe. 1924. 20 p. 28 cm. (Veröff. Badischen Landeswetterwarte. Nr. 5. Abhandlungen. Nr. 3, 1924.) [Includes: Der jährliche Gang der Temperatur in Baden, by J. Krauth.]

Philippot, H.
Expression analytique des variations de la température de l'air. Bruxelles. 1924. 48 p. figs. 29½ cm.

Vanderlinden, E.
Chronique des événements météorologiques en Belgique jusqu'en 1834. Bruxelles. 1924. 329 p. 29½ cm.

RECENT PAPERS BEARING ON METEOROLOGY

The following titles have been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

American meteorological society. Bulletin. Worcester, Mass. v. 5. 1924.
Atmospheric currents observed in large telescopes. p. 158–159. (November.) [Abstract.]
M[ilham], W[illis] I[sbister]. George Titus Todd. p. 162. (November.) [Obituary.]
Sanford, Fernando. The sun and atmospheric electricity. p. 157–158. (November.) [Abstract.]
Gregg, W. R. The free atmosphere in India. p. 169–170. (December.)

American society of heating and ventilating engineers. Journal. New York. v. 31. January, 1925.
McConnell, W. J., & Yagloglou, C. P. Work tests conducted in atmospheres of high temperatures and various humidities in still and moving air. p. 35–37.
Yagloglou, C. P., & Miller, W. Edw. Effective temperature with clothing. p. 59–70.

Arkiv för matematik, astronomi och fisik. Stockholm. Bd. 18. Häfte 3. no. 20, 1924.
Rossby, Carl-Gustaf. Thermisches Gleichgewicht in der Atmosphäre. 8 p.

Astronomical society of the Pacific. Publications. San Francisco v. 36. December, 1924.
Fisher, Willard J. The green flash—note on its history and literature. p. 325–326.
Perrine, C. D. On the cause of the green ray seen at sunset. p. 319–322.

Beiträge zur Physik der freien Atmosphäre. München. Band 11. 15. November, 1924.
Ahlborn, Fr. Die drei grossen Zirkulationen der Atmosphäre. p. 117–153.
Albrecht, F. Hygroskopische Widerstände und ihre Anwendung besonders in der aerologischen Hygrometrie. p. 164–180.
Friedmann, A. Ueber atmosphärische Wirbel und die Turbulenz des Windes. p. 154–163.
Polibaronowo, P. Zur Frage über die Turbulenz des Windes. p. 181–190.
Wegener, Alfred. Das Stehenbleiben der Registrieruhren in der Kälte. p. 113–116.

Carnegie institution of Washington. Washington. Year book no. 23. 1924.
Clements F. E., & Chaney, R. W. Principles and methods in paleo-ecology. p. 263–264. [Abstract.]
Clements, F. E. & Clements, E. S. Changes of climate and vegetation. p. 262–263. [Abstract.]
Douglass, A. E. Climatic cycles and tree growth. p. 261–262. [Abstract.]

Electrical world. New York. v. 84. January 24, 1925.
Butler, H. G. California power shortage of 1924. Drought experienced by power companies last year was the worst in forty years—how situation was met to produce least inconvenience and loss to consumers. p. 193–197.

Engineering news-record. New York. v. 94. January 1, 1925.
Highway snow removal practice summarized. Over a dozen States have large snow removal programs—organization, equipment, and costs reviewed—heavy drift-removal equipment illustrated. p. 4–6.

France, Académie des sciences. Comptes rendus. Paris. t. 179. 1924.
Petitjean, L. Sur le déplacement des fronts de discontinuité. p. 1279–1280. (1 décembre.)
Wehrlé, Ph., & Viaut, A. Sur la notion d'interférence en météorologie dynamique. p. 1276–1278. (1 décembre.)
Delcambre, E. L'œuvre météorologique du Jacques-Cartier. p. 1337–1339. (8 décembre.)
Maurain, Ch. Sur la propagation des ondes aériennes lors des expériences de la Courtine. p. 1334–1337. (8 décembre.)
Collignon, Maurice. Sur l'audition des ondes d'explosion à grande distance. p. 1615–1617. (29 décembre.)
Coyecque, M., & Wehrlé Ph. Les formations d'Hatteras. p. 1617–1620. (29 décembre.)

Geofysiske kommission. Geofysiske publikationer. Kristiania. v. 3, no. 6. 1924.
Bjerknes, J. Diagnostic and prognostic application of mountain observations.

Geographical review. New York. v. 15. January, 1925.
The oceanography of Barentz Sea and the climate of northern Europe. p. 147–148.
Visher, Stephen Sargent. Effects of tropical cyclones upon the weather of mid-latitudes. p. 106–114.
What is a desert? p. 151–152.

Ibérica. Tortosa. Año 11. 27 diciembre, 1924.
Del Junco y Reyes, Francisco. Segunda asamblea de la unión geodésica y geofísica internacional. Seccién de meteorología. p. 392–395.

Journal de physique et le radium. Paris. t. 5. Novembre 1924.
Bjerknes, V. Le problème des cyclones. p. 321–330.

Journal of geography. Chicago. v. 24. January, 1925.
Bullock. Emmarene. Weather maps and forecasts p. 23–26.

Marine observer. London. v. 2. 1925.
Lempfert, R. G. K. Sir Napier Shaw. p. 4–6. (January.) [With portrait.]
Shaw, Sir Napier. A meteorologist at sea, August 21–28, 1924. p. 2–3. (January).
Table cloth spread over Table Mountain. p. 6. (January.)
Dines, J. S. Meteorological office forecasts and the weather shipping bulletin. p. 17–19. (February.)
Durst, C. S. The doldrums of the North Atlantic. p. 20–22. (February.)

Mentor. New York. v. 9. February, 1925.
King, Clement. Climate and civilization. p. 62.

Meteorological magazine. London. v. 59. November, 1924.
Exposure of thermometer screens. p. 244–245.
Gomez, C. A. Report on hurricane experienced in Montserrat (West Indies), August 28th, 1924. p. 239–241.
Lempfert, R. G. K. The International union of geodesy and geophysics. Meeting in Madrid, October 1924. p. 229–232.
Shaw, Napier. The reform of the calendar. p. 236–238.

Nature. London. v. 114. 1924.
Nolan, J. J. Dust in the atmosphere. p. 720–722. (November 15.)
Vegard, L. Luminescence of solid nitrogen and the auroral spectrum. p. 715. (November 15.)
Goldie, A. H. R. The cause of cyclones. p. 786–787. (November 29.)
Deodhar, G. B. Polarisation of the light of rainbows. p. 860. (December 13.) [Also describes a duplication of the primary bow.]
Simpson, G. C. The electricity of thunderstorms. p. 890–891. (December 20.) [Review of books by Kähler.]
Jeffreys, Harold. The rare gases of the atmosphere. p. 934. (December 27.)

Nature. Paris. 52 année. 1924.
Boutaric, A. La lumière du ciel nocturne. p. 309–310. (15 novembre.)
Maurain, Ch. La physique du globe en Espagne. À propos du Congrès de geodésie et de géophysique de Madrid (1–8 octobre 1924.) p. 326–330. (22 novembre.) [Includes description and pictures of meteorological observatories.]
Marcotte, Edmond. La portée des signaux sonores et la transparence acoustique de l'air. Les échos singuliers et la prévision du temps. p. 372–379. (13 décembre.)
Mathias, E. Sur le bruit de l'éclair. p. 411–412. (27 décembre.)

Naturwissenschaften. Berlin. 12 Jahrgang. 1924.
Meissner, Otto. Kurze und lange Wasserstandsänderungen der Ostsee. p. 933–935. (7 November.)
Dorno, C. Die physikalischen Grundlagen der Sonnen- und Himmelstrahlung und ihre Anwendung in der Therapie. p. 1068–1075. (21 November.)
Kestner, Otto. Die Einwirkung des Klimas auf den gesunden und kranken Menschen. p. 1075–1079. (21 November.)

Philosophical magazine. London. v. 49. January, 1925.
Ono, Suminosuke. On orographic precipitation. p. 144–164.
Richardson, Lewis F. Turbulence and vertical temperature difference near trees. p. 81–90.

Royal astronomical society of London. Monthly notices. v. 85. November, 1924.
Yamamoto, Issei. On some relations between the solar constant and solar activity. p. 71–78.

Science, New York. v. 61. January 16, 1925.
Washburn, Edward W. Some effects of the atmosphere upon physical measurement. p. 49–56.

Société météorologique de France. Annuaire. Paris. t. 66. Années 1922–23.
Descombes, Paul. Les forêts, les pluies et les condensations occultes. p. 38–46.
Garrigou-Lagrange, P. Les grands mouvements de l'atmosphère et la prévision du temps. p. 34–37.
Guillaume, André. Influence du climat sur les limites de végétation dans le nord et l'est de la France. p. 1–21.
Maurain, Ch. Influence des vents dans la stratosphère sur la propagation du son. p. 28–33.
Moye, Marcel. Les brises locales sur les côtes du golfe de Lion. p. 22–27.
Pardé, Maurice. Les grandes pluies dans l'est des États-Unis. p. 47–62. [Review of Miami conservancy district, "Storm rainfall of the E. United States."]

Wetter. Berlin. 41. Jahrgang. September/Oktober, 1924.
Appelrath, Karl. Einige historische Daten über das Gefrieren des Bodensees. p. 157–158.
Die Asthmatiker bei einem Frontvorübergang. p. 154–155.
Fischer, Rudolf. Der August, 1924, der kälteste in Frankfurt a. Main seit 100 Jahren. p. 151–152.
Fischer, Rudolf. Sonnenflecken und Abweichung der meteorologischen Elemente von den Mittelwerten für Frankfurt a. M. p. 152–154.
Gockel, Albert. Ueber den Trübungsfaktor für Sonnenstrahlung und seine Verwendung zur Wetterprognose. p. 150–151.
Hartman, Wilhelm. Tropfengrösse und Tropfenbildung in der Atmosphäre. p. 129–135.
Peppler, W. Ein Beitrag zur Kenntnis des Nebels, besonders in Südwestdeutschland. p. 143–150.
Topolansky, Moriz. Eine andere Klimatherapie. p. 155-157.

SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING DECEMBER, 1924

By HERBERT H. KIMBALL, In Charge, Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January and February, 1924, **52**:42 & 113.

From Table 1 it is seen that solar radiation intensities averaged close to normal values at all three stations.

Table 2 shows that the total solar and sky radiation received on a horizontal surface averaged below normal at the three stations for which normals have been computed. For the year, Washington received an average amount of radiation, Madison 6 per cent less than the average, and Lincoln 1¾ per cent more than the average.

Skylight polarization measurements made on four days at Washington give a mean of 55 per cent with a maximum of 56 per cent on the 2d. These are below the corresponding averages for December at Washington. At Madison a measurement of 67 per cent on the 13th, with patches of snow on the ground, was below the average value for December at that station. After that date the ground was covered with snow.

TABLE 1.—*Solar radiation intensities during December, 1924*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date		Sun's zenith distance									
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Dec. 2	2.16	0.62	0.76	0.92	1.12	------	------	0.91	0.77	0.66	2.36
9	4.75	0.85	0.96	1.17	1.31	------	------	1.20	1.07	0.95	3.81
12	3.81	0.64	0.78	------	1.09	------	------	1.05	------	------	4.17
13	5.56	------	------	------	1.26	------	------	------	------	------	5.17
19	7.57	------	------	------	1.01	------	------	0.81	------	------	8.81
26	1.19	------	1.06	1.20	1.35	------	------	1.13	0.99	0.88	1.45
Means	------	0.70	0.89	1.10	1.19	------	------	1.02	0.94	0.83	------
Departures	------	−0.08	±0.00	+0.05	−0.03	------	------	+0.01	+0.05	+0.05	------
		Madison, Wis.									
Dec. 1	1.78	------	------	------	------	------	------	1.01	------	------	1.88
2	2.06	------	0.88	------	------	------	------	------	------	------	3.45
10	1.07	------	1.00	1.17	------	------	------	------	------	------	1.52
13	3.45	1.04	------	1.32	------	------	------	------	------	------	1.96
19	0.86	------	------	------	------	------	------	1.29	------	------	0.51
20	0.43	------	1.19	1.29	------	------	------	------	------	------	0.56
22	0.79	------	0.97	1.15	------	------	------	------	------	------	1.02
24	0.58	------	------	1.34	------	------	------	------	------	------	0.48
Means	------	(1.04)	1.01	1.25	------	------	------	(1.15)	------	------	------
Departures	------	+0.08	−0.09	+0.02	------	------	------	−0.14	------	------	------

*Extrapolated.

TABLE 1.—*Solar radiation intensities during December 1924*—Con.

Lincoln, Nebr.

[Gram-calories per minute per square centimeter of normal surface]

Date	Sun's zenith distance										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Dec. 1	3.45	1.01	1.12	1.25							2.49
9	1.52							1.22			1.96
15	3.00	0.88	0.97	1.14							4.57
19	0.53							1.35	1.17		0.64
22	0.96							1.08			1.12
Means		(0.94)	(1.04)	(1.20)				1.22	(1.17)		
Departures		±0.00	−0.01	−0.03				+0.02	+0.10		

* Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation					Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Washington	Madison	Lincoln
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Dec. 3	90	67	104	57	94	−57	−54	−72
10	146	115	157	73	85	+3	−9	−16
17	134	148	143	56	87	−9	+21	−31
24 *	121	153	168	83	110	−25	+21	−11
Excess or deficiency since first of year on Dec. 31, 1924						−6	−7402	+2445

* For eight days.

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

The following table shows the average sea-level pressure for the month at a number of land stations on the coast and islands of the North Atlantic. The readings are for 8 a. m., 75th meridian time, and the departures are only approximate, as the normals were taken from the Pilot Chart and are based on Greenwich mean noon observations, which correspond to those taken at 7 a. m., 75th meridian time.

Stations	Average pressure	Departure
	Inches	*Inches*
St. Johns, Newfoundland	29.70	−0.18
Nantucket	30.11	+0.04
Hatteras	30.21	+0.08
Key West	30.14	+0.05
New Orleans	30.19	+0.07
Swan Island	29.98	−0.01
Turks Island	30.13	+0.10
Bermuda	30.28	+0.14
Horta, Azores	30.22	+0.11
Lerwick, Shetland Islands	29.52	−0.26
Valencia, Ireland	29.74	−0.21
London	29.99	−0.02

The average pressure at Horta being somewhat above normal, while at Lerwick it was considerably below, denotes that the Azores HIGH and Icelandic LOW were well developed with a steep gradient between the two centers of action. At Horta the barometric readings ranged from 29.64 inches on the 20th to 30.52 inches on the 24th, and at Lerwick from 28.35 inches on the 27th to 30.18 inches on the 21st.

In each month from September to December, 1924, inclusive, the number of days with winds of gale force over the steamer lanes was greater than the normal as shown on the Pilot Chart. The maximum number of stormy days was reached in the month under discussion, when in the region between the 45th and 50th parallels and the 25th and 45th meridians gales were reported on from 12 to 14 days. These conditions are abnormal even for December, which, with the exception of January, is considered the stormiest month of the year over the North Atlantic.

Judging from reports received, the number of days with fog was somewhat less than usual over the Grand Banks; it apparently occurred with about its normal frequency off the American coast and somewhat above in northern European waters, while the steamer lanes were comparatively free. Fog was also reported on two days in the western part of the Gulf of Mexico, two days off the coast of Portugal, and one day in the vicinity of the Azores.

From the 1st to 3d there were two well-developed disturbances in northern waters; the first central in the vicinity of Newfoundland and the second off the coast of northern Europe. The storm area of the western LOW extended as far south as the 35th parallel, while on the 1st and 2d the eastern disturbance was restricted to the region between the 45th and 50th parallels and the 15th and 25th meridians. According to reports received this latter storm was intermittent in character, with a period of comparatively moderate weather between the heavy winds occurring at the time of observation on the 1st and 2d, and was recorded by some observers as two separate gales. On the 1st winds of gale force were also reported by vessels about midway between these two LOWS. On the 4th the western disturbance was central near 50° N., 35° W.; it moved rapidly eastward and on the 5th was near 50° N., 20° W. On both dates strong westerly gales prevailed in the southerly quadrants.

On the 5th St. Johns, Newfoundland, was near the center of another depression, that by the 7th was central near 45° N., 40° W.; it then apparently curved sharply northeastward, although the position on the 8th was uncertain, due to lack of observations.

On the 5th and 6th the trade winds were unusually well developed over the region between the Canal Zone and Jamaica, as shown by storm report in table.

On the 9th a depression covered the province of Quebec; this moved eastward increasing in intensity, and on the 11th the center was near 50° N., 35° W., and by the 12th about 15° west of the coast of Scotland. Moderate to strong gales prevailed on both of these dates in mid-ocean, and on the 12th southerly winds of gale force were also reported in the easterly quadrants.

From the 13th to 15th a deep and slowly moving depression was off the American coast, which during that period was swept by strong westerly gales from Hatteras to Newfoundland; on the 16th the depression began to move rapidly eastward, reaching European waters by the 18th.

From the 14th to 16th there was a well-developed disturbance over the eastern section of the steamer lanes that reached its greatest intensity on the 15th.

On the 18th St. Johns, Newfoundland, was again near the center of a LOW and moderate gales were reported from vessels between the 30th and 40th parallels and 50th and 55th meridians. On the 19th heavy weather

prevailed over the greater part of the region between the 35th and 55th parallels and the 20th and 45th meridians.

On the 20th there were two well-developed depressions over the ocean; the first in the vicinity of Nova Scotia and the second near 55° N., 25° W. The general conditions were not unlike that of the 19th, except that on the 20th moderate gales were reported from vessels between the Bermudas and Canadian coast.

On the 19th and 20th there was a strong "norther" in the Gulf of Mexico, due to the steep gradient shown on the daily weather map of the 20th, with a barometric reading at Galveston of 30.54 inches and at Swan Island 29.98 inches.

Charts VIII to XIV cover the period from the 21st–27th, inclusive, and an examination of these maps together with the table of Ocean Gale and Storm reports will give a good idea of the very unusual conditions that existed during this period.

On the 27th at Greenwich mean noon the barometric reading at Reykjavik, Iceland, was approximately 27.79 inches, and at Horta, Azores, 30.22 inches. The steep gradient between the Azores HIGH and Iceland LOW continued for the remainder of the month, and in consequence the steamer lanes were swept by unusually severe westerly gales.

OCEAN GALE AND STORM REPORTS, DECEMBER, 1924

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer (ins.)	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
North Atlantic Ocean			° ′	° ′									
Asia, Fr. S. S.	Gibraltar	New York	37 30 N.	66 15 W.	Nov. 30	1st	2d	28.57	NW.	W.	SW.	—, 10	Steady W.
Baron Sempill, Br. S. S.	Fowey, England.	Boston	47 24 N.	40 05 W.	1st	8 p., 1st	2d	29.83	WSW.	WSW., 10.	WSW.	WSW., 11.	Steady WSW.
Wellfield, Br. S. S.	Rotterdam	New York	49 42 N.	11 10 W.	1st	11 a., 1st	1st	28.92	SW.	W., 5.	NW.	NW., 9.	SW-W-NW.
Do	do	do	49 33 N.	15 50 W.	2d	7 a., 2d	2d	29.03	SW.	W., 8.	W.	NW., 10.	SW-W-NW.
Meltonian, Br. S.S.	Liverpool	Boston	49 30 N.	30 30 W.	4th	10 a., 4th	5th	29.14	W.	SW., 8.	W.	—, 10.	W-SW.
Canadian Prospector, Br. S. S.	Panama	do	13 04 N.	77 29 W.	5th	Noon, 5th	6th	29.90	E.	E., 7.	ENE.	—, 8.	E-NE-E.
Chicago, Fr. S. S.	Vigo	New York	44 37 N.	40 38 W.	5th	2 a., 6th	6th	29.58	S.	S.	N.	WNW., 11.	
Bellatrix, Du. S. S.	Montreal	Naples	45 33 N.	42 50 W.	9th	3 p., 10th	12th	29.52	S.	SW., 7.	NW.	W., 9.	SW-W.
West Quechee, Am. S.S.	Manchester	Philadelphia	35 50 N.	67 10 W.	13th	11 p., 13th	15th	29.54	SSW.	SSW., 10.	NW.	—, 10.	SSW-WSW.
American Banker, Am. S. S.	London	New York	42 58 N.	58 03 W.	14th	7 a., 14th	17th	29.47	W.	W., 7.	W.	W., 11.	Steady W.
Breedijk, Du. S. S.	Norfolk	Rotterdam	48 20 N.	24 45 W.	13th	7 p., 14th	16th	29.60	SSE.	WSW., 10.	NNW.	W., 10.	WSW-W.
Emanuel Nobel, Belg. S. S.	Rouen	Marcus Hook	50 30 N.	22 10 W.	17th	11 p., 17th	18th	29.44	S.	SW., 10.	W.	W., 11.	S-SW-W.
F. H. Hillman, Am. S.S.	Panama	England	31 41 N.	41 07 W.	18th	4 a., 20th	20th	29.85	SW.	WNW.	WNW.	WNW., 10.	Steady WNW.
Gedania, Danzig S. S.	Tampico	Baltimore	21 35 N.	95 50 W.	19th	Mid., 19th	20th	30.12	N.	N., 10.	NNW.	N., 10.	E-N-NNW-N.
Bidwell, Am. M. S.	Denmark	Marcus Hook	58 07 N.	21 56 W.	20th	3 a., 20th	20th	29.10	SE.	SSE., 9.	SSW.	—, 9.	SSE-SE.
Ampetco, Belg. S. S.	Antwerp	Paulsboro, Pa.	48 44 N.	32 08 W.	17th	2 p., 21st	26th	28.56	SW.	WNW., 12.	WNW.	WNW., 12.	SSE-WNW.
Maine, Dan. S. S.	Newcastle	Miami, Fla.	41 45 N.	35 56 W.	21st	11 a., 21st	23d	29.35	WSW.	WSW., 10.	NNW.	W., 12.	WSW-WNW.
Emanuel Nobel, Belg. S. S.	Rouen	Marcus Hook	48 43 N.	39 00 W.	21st	5 a., 22d	24th	29.12	S.	W., 12.	NW.	—, 12.	S-W-NW.
Parthenia, Br. S. S.	Glasgow	St. John, N. B.	54 34 N.	19 16 W.	20th	Noon, 22d	23d	28.77	SW.	S., 11.	WSW.	—, 11.	S-SW.
Bidwell, Am. M. S.	Denmark	Marcus Hook	48 40 N.	41 05 W.	24th	3 a., 26th	28th	29.20	NW.	W., 7.	W.	—, 11.	SSW-WSW-WNW.
Nubian, Br. S. S.	Boston	Liverpool	45 27 N.	41 02 W.	25th	8 a., 26th	27th	29.60	SW.	WSW., 8.	W.	NW., 12.	SW-WSW-NW
Eemdijk, Du. S. S.	Cristobal	do	50 49 N.	10 24 W.	19th	4 p., 27th	27th	29.08	SW.	WSW., 8.	WSW.	WSW., 11.	Steady WSW.
Oilfield, Br. S. S.	France	Halifax, N. S.	50 00 N.	13 00 W.	29th	7 p., 29th	30th	29.39	SW.	WNW., 10.	W.	SSW., 10.	SSW-WNW.
Clavarack, Am. S. S.	Mobile	Rotterdam	41 35 N.	41 55 W.	28th	4 a., 29th	30th	29.86	N.	N., 5.	NW.	—, 9.	W-NW-N.
Blijdendijk, Du. S. S.	Rotterdam	Boston	49 37 N.	20 25 W.	30th	4 p., 30th	31st	29.50	WSW.	W., 9.	WSW.	W., 9.	W-SW-W.
Devonian, Br. S. S.	Liverpool	Halifax, N. S.	50 57 N.	25 05 W.	31st	10 p., 31st	Jan. 1	28.98	SSW.	W., 8.	W.	SSW., 9.	SW-W.
North Pacific Ocean													
Eburna, Br. S. S.	Borneo	Yokohama	20 20 N.	122 15 E.	Nov. 30	10 p., 30th	Dec. 2	29.88	NE.	NE., 8.	ENE.	NE., 10.	Steady.
Tahchee, Br. S. S.	San Francisco	Manila	29 45 N.	176 30 W.	Dec. 2	7 a.	2d	29.80	SSW.	SSW., 8.	SW.	SW., 8.	
Pres. Cleveland, Am. S. S.	Manila	Yokohama	18 14 N.	117 44 E.	3d	Noon, 3d	4th	29.56	S.	S., 6.	N.	ENE., 10.	SSE-ENE.
Montgomery City, Am. S. S.	San Pedro	do	31 32 N.	177 44 E.	5th	2.30 p., 5th	6th	29.64	WSW.	WSW.	WNW.	—, 8	W by S-W.
West Cayote, Am. S. S.	Portland, Oreg.	do	45 00 N.	155 00 E.	5th	1 p., 5th	6th	29.64	SSW.	NW., 8.	WNW.	NW., 9.	SSW-W-NW.
West Ivan, Am. S. S.	Hongkong	San Francisco	34 48 N.	175 48 W.	6th	1 p.	6th	29.51	SW.	SW., 8.	WSW.	SW., 8.	SW-WSW.
Tamaha, Br. S. S.	Shanghai	do	37 40 N.	149 20 E.	8th	1 p., 8th	10th	29.58	ESE.	S.	N.	WNW., 10.	SE-S-WSW.
West Cayote, Am. S. S.	Portland	Yokohama	40 N.	145 E.	8th	4 p., 8th	9th	29.65	SE.	NW., 9.	NNW.	W by N, 10.	SE-E-NW.
West Ivan, Am. S. S.	Hongkong	San Francisco	35 N.	161 W.	10th	5 a., 10th	11th	28.91	SW.	SW., 10.	SW.	SW., 10.	S-SW.
Dickenson, Am. S. S.	Honolulu	Midway Is.	25 53 N.	174 13 W.	9th	7 p., 9th	10th	29.54	SW.	SW., 9.	NW.	WSW., 9.	SW-WNW.
Eastern Prince, Br. S. S.	Panama	Yokohama	22 22 N.	161 W.	11th	4 p.	11 th	29.79	SW.	NW., 8.	NW.	NW., 9.	SW-W-NW.
Memphis, City, Am. S. S.	San Pedro	do	33 45 N.	141 E.	11th	8 p., 11th	12th	29.49	W.	W., 6.	W.	W., 11.	W-NW-W
Montgomery City, Am. S. S.	do	do	31 10 N.	149 E.	12th	Mid., 12th	14th	29.61	WSW.	SW.,	NW.	—, 10.	WSW-W.
Yokohama Maru, Jap. S. S.	Yokohama	Victoria	49 25 N.	173 20 W.	12th	1 a., 14th	14th	29.41	S.	S., 10.	SW.	S., 11.	
Pres. Madison, Am. S. S.	Seattle	Yokohama	51 55 N.	165 07 W.	14th	10 p.	14th	29.85	S. by E.	SSW. 7.	SSW.	SSE. 10.	SSE-S-SSW.
Eldridge, Am. S. S.	Manila	Seattle	48 15 N.	173 30 E.	17th	11 p., 17th	19th	29.00	E.	ENE. 7.	SSW.	S. 11.	SE-SSW.
Tamaha, Br. S. S.	Shanghai	San Francisco	40 12 N.	145 45 W.	19th	1 p., 21st	21st	29.42	E.	E. 8.	S.	E. 9.	E-SE-S.
Emp. of Aus., Br. S. S.	Yokohama	Victoria	50 30 N.	148 15 W.	21st	8 a., 22d	22d	29.97	ENE.	ESE., 9.	E by S.	E., 9.	E-ESE-E.
Pomona, Am. S. S.	Everett	Balboa	15 30 N.	96 W.	21st	2 p., 21st	22d	29.97	ENE.	N., 8.	N.	N., 8.	ENE-N.
Harold Dollar, Br. S.S.	San Pedro	Japan	32 58 N.	161 25 E.	22d	2 p., 22d	23d	29.56	NW.	NW., 9.	WNW.	NW., 11.	SW-NNW.
Pres. Harrison, Am. S. S.	Honolulu	Kobe	33 30 N.	159 40 E.	22d	10 p., 22d	23d	29.38	SE.	N., 12.	NW.	N., 12.	SE-N.
West Cajoot, Am. S. S.	Hongkong	San Francisco	38 25 N.	175 E.	23d	10 a., 23d	24th	28.95	NE.	N., 10.	NW.	N., 10.	NE-N.
West Jena, Am. S. S.	Portland	Yokohama	34 55 N.	154 30 E.	24th	10 a., 24th	25th	29.45	NW.	NW., 6.	NW.	NW., 10.	Steady.
Ibuskian Maru, Jap. S. S.	Yokohama	San Francisco	47 05 N.	180	25th	4 p., 27th	27th	28.56	N.	NNE., 6.		NNE., 8.	NNE-N.
West Cajoot, Am. S. S.	Hongkong	do	38 20 N.	171 45 W.	26th	4 a.	26th	28.65	SW.	SW., 8.	SW.	SW., 9.	Steady.
Stockton, Am. S. S.	Cebu	Portland	21 35 N.	132 10 E.	26th	11 p., 26th	27th	29.82	NW.	NW., 10.	N.	NW., 10.	
Havre Maru, Jap. S. S.	Japan	Grays Harbor	48 20 N.	172 11 E.	26th	11 p., 27th	28th	28.86	N by W	NW by N.	WNW.	NNW., 9.	
Pres. Jefferson, Am. S. S.	Yokohama	Seattle	48 20 N.	177 E.	26th	10 a.	30th	28.94	NW.	W., 9.	WNW.	W., 9.	NW-W-WNW.
Ibukisan Maru, Jap. S. S.	do	San Francisco	47 45 N.	165 20 W.	29th	6 p., 29th	31st	28.46	NE.	N., 7.		SW., 9.	N-NW-W.
Anna E. Morse, Am. S. S.	do	Portland	46 35 N.	153 W.	29th	1 a., 30th	Jan. 2	28.79	S.	SSW., 8.	WSW.	W., 10.	SSW-W.

NORTH PACIFIC OCEAN

By WILLIS EDWIN HURD

For the first time in many months no reports of fog occurring west of the 180th meridian for a given month have come in from marine observers crossing the North Pacific Ocean. Otherwise, south of the Aleutian Islands, and along the northern and central sailing routes, fog was moderately frequent in December. Along the 5-degree strip, 45° to 50° N., between 180° and the Washington coast, scattered observances of the phenomenon were made on 15 days. Down the American coast to the 28th parallel fog was less frequently reported than in November. In the 5-degree square southwest of Guatemala it occurred on the 5th, 19th, and 20th. The U. S. S. *Sirius* makes the following report of fog in 13° 30′ N., 92° 17′ W.:

Dec. 5. This heavy fog was preceded by rapid fall in temperature of injection water. At 1 a. m. injection was 84°; 2 a. m., 72°; then a slow decrease to 69° at 8 a. m. It is thought probable this sudden drop in water temperature caused condensation of water vapor into the hotter air and produced the fog. During the occurrence the air temperature was 77° to 86°. This report is particularly submitted since fog appears to be an unusual phenomenon in this vicinity at this period of year.

Gales this month occurred over a wider expanse of the ocean, and were less concentrated as to given area, than is usually observed. In general, however, there was a more southward migration of strong winds, and an unusual number of gales were reported as low as 20° to 25° N. in mid-ocean. Storm to hurricane winds were reported by vessels on the 1st, 11th, 14th, 17th, 21st, and 22d, and hurricane velocities were recorded at the Tatoosh Island Weather Bureau Station on the 19th and 20th.

A rather unusual pressure situation was associated with these conditions. While stable high pressure prevailed over the China coast, and resulted on some days in a strong northeast monsoon current, the wind at times reaching a force of 10, there was a considerable inversion of the pressure elements east of the 180th meridian, and for the middle half of the month the region of the Aleutian LOW was covered by an anticyclone, while cyclonic conditions prevailed to the southward. Some idea of this situation may be had by a consideration of the barometric situation at the three island stations of Dutch Harbor, Midway Island, and Honolulu.

The mean pressure for December, 1924, at Dutch Harbor was 29.72 inches, which was 0.17 inch above the normal. From the 1st to the 24th, with the exception of the 6th to 8th, the daily 8 p. m. readings were higher than the average, 30.46 on the 20th being the highest. About the 20th the huge LOW that had covered much of middle latitudes for a decade began to forge northeastward toward southwestern Alaska until, on the 25th, pressure fell below normal at Dutch Harbor, reaching its minimum reading of 28.88 on the 29th. At the close of the month the Aleutian LOW, so-called, had advanced until all Alaska was under its influence. The pressure extremes at Kodiak were 30.86, on the 20th, and 28.42, on the 8th.

At Midway Island the average 8 p. m. pressure was 29.92 inches, or 0.10 inch below the normal, and 0.28 inch below the average of December, 1923. The daily readings were above normal on eight occasions only, or from the 11th to 15th, and the 29th to 31st. The highest was 30.22, on the 29th and 30th; the lowest, 29.50, on the 22d.

At Honolulu the average pressure was 29.97 inches, as against the normal of 30.02, and the extremes were 30.19, on the 31st and 29.61 on the 16th. The minimum reading was the third lowest ever made at Honolulu, the absolute lowest being 29.51, in December, 1906. Pressure was below normal except on the 1st to 5th, on the 22d, and from the 26th to 31st. Thus it will be seen that this station was under the influence of the eastern North Pacific anticyclone during the first and last few days of the month, and during most of the other 20 days was in regions of diminished pressure. From the 11th to the 18th of this period an area of low pressure, detached from the principal cyclone, was especially affecting the Hawaiian region. As a consequence, although the prevailing monthly wind was east at Honolulu, yet a kona, or southwest wind, was unusually strong and long-continued. The maximum wind velocity was at the rate of 39 miles an hour from the southwest, on the 17th and 20th. Honolulu's maximum temperature was 83°, on the 1st, which is the highest in December since 1894. The minimum was 61°, on the 13th, the lowest since 1906.

Along the coast of Washington and Oregon precipitation was in excess of the average, and temperatures were below the normal. While, owing to the persistent anticyclone, both precipitation and temperature were generally below normal after the 11th in southeastern Alaskan waters.

The eastern North Pacific HIGH, normally central between Hawaii and California, was subject to great fluctuations, but was well developed near its usual area on the early and last days of the month, and during the high-pressure period over Alaska, extended generally in a ridge down over the eastern waters of the ocean. More frequently than not the crest of the HIGH lay over the American continent.

In the Far East tropical storm development continued light, as in November, with only three typhoons in the two months. On the 3d the American S. S. *President Cleveland* encountered an east-northeast gale, force 10, lowest pressure 29.56, midway between Manila and Hongkong. This seems to have been close to the final record of the typhoon which traversed the Philippines on November 29. The typhoon of December 13–22 is noticed by the Rev. José Coronas in his article entitled "One Typhoon over the Philippines in December, 1924," appearing elsewhere in this issue of the REVIEW.

As usual, the waters of the Gulf of Tehuantepec and neighborhood were disturbed by northerly gales on several days, as experienced by vessels plying to and from Panama.

The attached table gives a good indication of the distribution and force of the December gales. The heavier sea winds recorded occurred, as a rule, to the westward of 180°. On the first and eleventh storm to hurricane winds occurred in connection with cyclonic disturbances east or southeast of Japan. No very low pressures accompanied either, but in the first instance the British S. S. *Canadian Winner* encountered terrific snow and hail squalls in 40° N., 145° E., while in the second the American S. S. *Memphis City* faced a westerly gale of force 11, accompanied by rain, a few miles outside of Yokohama Harbor. On the 14th and 17th storm winds were experienced by vessels south of the western Aleutians, and on the 21st and 22d hurricane blasts occurred in connection with moderately shallow pressures near 33° N., 160° to 165° E.

It is frequently noticeable that only fresh to strong gales occur, or at least are observed, coincident with the lowest pressure readings in the huge Pacific cyclones. Thus, in the table, we see the American S. S. *President Harrison* encountering a hurricane, lowest observed

pressure 29.38, in 33° N., 160° E., on the 22d, while vessels in the Aleutian region toward the center of the great winter LOW experienced pressures much lower than 29 inches, with only moderate winds. The lowest pressure recorded in these waters by a vessel this month was 28.46 inches, read on board the Japanese S. S. *Ibukisan Maru*, in 47° 45′ N., 165° 20′ W., on the 29th, highest wind force 9 SW. Of course steepness of pressure gradient in large measure determined the relative strength of these winds.

NOTE

American S. S. *Pacific*, Puget Sound southward.—December 6, latitude 47° 10′ N., longitude 124° 33′ W. Sighted moderate waterspout about 2 miles to westward.

ONE TYPHOON OVER THE PHILIPPINES IN DECEMBER, 1924

By REV. JOSÉ CORONAS, S. J.

[Weather Bureau, Manila, P. I.]

There has been only one really well-developed typhoon in the Far East during this month of December; and this is the one that traversed the central part of the Philippines on the 19th and 20th and influenced the weather in most of our southern stations for eight or more successive days. Heavy, prolonged rains with destructive floods have been reported, particularly from places in Surigao, Cebu, Samar, and Leyte provinces. Great landslides have been also reported as an effect of heavy continuous rains in the Province of Surigao. Our observer at Surigao has reported the following daily amounts of rain in that place for the period of December 11 to 15, the heavy rains having begun even two days before the typhoon was noticed to the east of Surigao: December 11, 190.6 millimeters (7.50 inches); December 12, 183.5 millimeters (7.23 inches); December 13, 223.1 millimeters (8.78 inches); December 14, 328.9 millimeters (12.95 inches); December 15, 93.9 millimeters (3.70 inches); total in five days, 1,020 millimeters (40.16 inches).

The typhoon was first shown by our weather maps on December 13, between Yap and Mindanao, not far from 133° longitude E., between 9° and 10° latitude N. It moved probably west by north until the 15th, when it inclined northward near to the east of Surigao Strait. Then it remained almost stationary, or continued moving very slowly in the 16th, 17th, and part of the 18th, until finally in the afternoon of the 18th it inclined decidedly to the west.

On the 19th warnings were sent to the effect that the typhoon was moving practically west from the Strait of San Bernardino, threatening Romblon and Mindoro. In fact, the center passed over San Bernardino Strait, where the vortical calm was observed on board the steamer *Ulises* (barometric minimum 742 millimeters, 29.21 inches, shortly after noon of December 19; and over Romblon, where absolute calm was also reported by our observer at 8 a. m of December 20. The rate of progress of the typhoon was of about only 6 to 7 miles per hour on the 19th and 20th.

In the China Sea the typhoon continued moving west until the afternoon of the 21st, when it inclined to west-northwest. In the afternoon of the 22d the center was situated in about 115° longitude E and 14° latitude N., where it has at this writing (December 25) remained almost stationary for about two days, probably filling up gradually.

The position of the center at 2 p. m. of December 19, 20, and 21, and 6 a. m of December 20, 21, and 22, was as follows:

December 19, 2 p. m., 124° 10′ longitude E., 12° 40′ latitude N.

December 20, 6 a. m., 122° 25′ longitude E., 12° 40′ latitude N.

December 20, 2 p. m., 121° 35′ longitude E., 12° 40′ latitude N.

December 21, 6 a. m., 119° 05′ longitude E., 12° 45′ latitude N.

December 21, 2 p. m., 117° 25′ longitude E., 12° 50′ latitude N.

December 22, 6 a. m., 116° 10′ longitude E., 13° 15′ latitude N.

DETAILS OF THE WEATHER IN THE UNITED STATES

GENERAL CONDITIONS

ALFRED J. HENRY

Practically a normal month up to the 18th when a southward flow of cold air from high latitudes set in, culminating on the 21st in extraordinarily high pressure over the Rocky Mountain and Plateau regions. The effect of the high pressure and associated low temperature was felt until about the end of the month. The usual details follow:

CYCLONES AND ANTICYCLONES

By W. P. DAY

The barometric pressure was abnormally high over Alaska from the 12th until the 28th, reaching its first great maximum on the 14th at Eagle. Meanwhile, this condition spread southeastward and reached Alberta on the 15th and carried as far as the lower Missouri Valley. With one or two interruptions the Alaska HIGH spread slowly southeastward until by the 21st there was one area of continuously high pressure extending from the northwestern limits of Alaska to the Atlantic coast. The southeastward movement of this great mass of cold air had been retarded by the persistance of high pressure extending westward from Bermuda, but it finally prevailed. Following the breaking down of the area over the United States on the 23d, three more important HIGHS from the parent HIGH in Alaska appeared in the northwest before the close of the month. The large area covered by the individual HIGHS prevented their being so numerous as in the preceding month.

The low-pressure areas after the 15th followed the southern circuit, or appeared first in northern Manitoba. They were less numerous than in November.

FREE-AIR SUMMARY

By V. E. JAKL

It will be noted from Table 1 that there was a pronounced deficiency in temperature at all aerological stations, except Due West, where about normal temperatures prevailed. The departures in the levels near the ground are in agreement with Chart 111, which shows that the greatest fall in temperature below the normal occurred over the Northwestern States. A closer inspection of Table 1 shows that the negative departures diminished in magnitude with increasing altitude, except that

at some stations there was first an increase in the amount of negative departure with altitude up to about 750 meters. As the departures were due mostly to the cold weather in the latter half of the month, beginning with the cold wave that swept over the country from the 15th to 21st, it is of interest to examine some of the upper-air records made during the prevalence of the cold wave, in order to account for the observed gradation of negative departures with altitude. The records at Ellendale for the 16th, 18th, 19th, and 20th, showing upper-air temperatures and winds, and surface pressures, are reproduced in the following table to illustrate the development of the cold wave, first in the lower levels, and later in the higher levels as the HIGH was reinforced. On the 20th, when the HIGH had about reached its crest stage over Ellendale, low temperatures extended from the ground to 4,800 meters, with a change to warmer, as compared with the previous three days, recorded in intermediate altitudes. The records of some of the other aerological stations, notably Drexel, show substantially the same sequence of conditions attending the passage of the cold wave.

Altitude, M. S. L. (meters)	16th			18th			19th			20th		
	Pressure, mb.	Temperature, °C.	Wind direction	Pressure, mb.	Temperature, °C.	Wind direction	Pressure, mb.	Temperature, °C.	Wind direction	Pressure, mb.	Temperature, °C.	Wind direction
444 (surface).	976.2	−24.9	n.	980.4	−29.6	wnw.	980.9	−27.5	wnw.	988.3	−30.5	sw.
750	-----	−28.2	n.	-----	−30.0	wnw.	-----	−23.9	nw.	-----	−21.2	wnw.
1,000	-----	−29.1	n.	-----	−27.9	wnw.	-----	−22.5	nw.	-----	−21.2	nw.
1,250	-----	−29.8	nne.	-----	−28.0	wnw.	-----	−23.3	nw.	-----	−20.4	wnw.
1,500	-----	−28.5	nne.	-----	−27.4	wnw.	-----	−24.2	nw.	-----	−20.8	wnw.
2,500	-----	−12.7	nw.	-----	−19.0	wnw.	-----	−27.8	nw.	-----	−25.3	wnw.
2,800	-----	− 3.8	w.	-----	-----	-----	-----	−29.1	nw.	-----	−26.7	wnw.
3,000	-----	-----	-----	-----	-----	-----	-----	−29.9	nw.	-----	−26.7	wnw.
4,800	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	−35.4	wnw.

This characteristic of the cold wave, connoting as it does a wedge-like front, suggests an explanation of the broad band of precipitation in the form of rain, sleet, and snow that progressed south and southeastward on its front from the 17th to 20th. This was particularly evident in the lower latitudes where great contrasts in temperature and humidity occurred. At Broken Arrow the aerological records show a fall in temperature from the 16th to 19th in the column of air extending up to 2,000 meters, ranging from the highest of record for any December, on the 16th, to a similarly lowest of record on the 19th. At this station heavy precipitation occurred on the 17th and 18th, and while no flights were possible on these dates there appears to be satisfactory evidence that the surface condition of northerly winds and falling temperature was surmounted by winds aloft having south component. The aerological observation on the 19th, extending to 1,600 meters in northerly winds, shows a marked inversion of temperature and falling off in wind velocity at the highest level, indicating the likelihood of a reversal of wind direction at a still higher altitude. In addition, the aerological and cloud observations on the 18th at Groesbeck, 300 miles to the south, show south component winds to high altitudes.

Wind resultants from both kite and pilot-balloon observations covering all portions of the country east of the Rocky Mountains, showed the general trend ro the west, normal for the month. In the upper levels the winds were about due west, while in the lower levels, there was a south component, except over the northern Plains States, where the lower altitude winds had a pronounced northerly component. At Drexel and Ellendale in fact, the northerly tendency of the winds persisted, although with diminishing degree, to the highest levels observed.

Resultant velocities for all stations were decidedly above normal throughout the vertical range of observations, except near the ground. (See Table 2.) A rapid increase in velocity with altitude was characteristic of the month at most stations; consequently the resultant upper-air velocities were generally above normal, particularly in the highest altitudes for which reliable averages were obtained. An examination of the individual records and comparison of them with weather maps at corresponding times, showed that the high velocities aloft so frequently observed were correlated with the general pressure distribution over the country, rather than with the surface pressure gradients at the particular places of observations. As an example chosen from a number of instances of this apparently anomalous relation, the two-theodolite pilot-balloon observation at Broken Arrow on the 10th is cited. This was made in the crest of a high-pressure area, and as might be expected from the absence of perceptible pressure gradient, a state of virtual calm—in this case extending to about 1,000 meters—existed in the lower levels. Above 1,000 meters there was a steady increase in velocity to 23 meters per second from the west at 5,000 meters. Vigorous LOWS to the north and northeast of Broken Arrow and strong winds aloft from a general westerly direction at most aerological stations on this date, indicated a pronounced north-south pressure gradient in the higher altitudes over a considerable portion of the country, irrespective of surface pressure conditions. A relation is therefore suggested between the observed frequency and widespread occurrence of strong upper-air winds and the general vigor in development and movement of HIGHS and LOWS that was a feature of the month.

Among the observations made under the influence of strong surface pressure gradients, two examples are cited, representing the widely divergent wind effects, as regards change in velocity with altitude, associated with well defined LOWS and HIGHS. The first is an observation made at Ellendale on the 22d in the south portion of a vigorous LOW, in which the velocity rose from 16 meters per second on the ground to 28 meters per second at 1,500 meters. The other example is given in the record of the pilot balloon observation at Groesbeck on the 19th, where in the front of the cold wave HIGH previously referred to, wind velocity fell off from 16 meters per second on the ground to 6 meters per second at 1,900 meters. The explanation is to be found in the very steep horizontal temperature gradients, indicating a rapid readjustment of pressure gradient with altitude, and a probable reversal of direction of pressure gradient at some upper level. The record of cloud direction on this date supports the inference of a south component wind above the upper limit of pilot balloon observation.

An aerological record giving undeniable evidence of recurving of colder air from the rear to the front of a LOW is furnished by the kite observations at Broken

Arrow on the 3d and 4th.[1] The position of the LOW with reference to Broken Arrow changed from a point a considerable distance west of Broken Arrow on the 3d, to a short distance north of that station on the 4th. The change to colder in the southerly winds over Broken Arrow is apparent in the comparative temperatures of the 3d and 4th, but is more directly evident in the falling temperature in the levels up to 1,500 meters recorded during the progress of the flight on the 4th. The following table is an abstract of the observations on these dates:

Altitude, M. S. L. (meters)	3d		4th					
	Temperature, ° C.	Wind direction	Time, a. m.	Temperature, ° C.	Wind direction	Time, a. m.	Temperature, ° C.	Wind direction
233 (surface)	8.2	SSE	8.14	9.2	S	10.59	7.2	SW.
500	8.8	S	8.18	7.8	S	10.56	4.8	SSW.
1,000	11.7	SSW	8.28	4.3	S	10.43	1.0	S.
1,500	8.1	SSW	8.39	1.6	SSW	10.30	−1.4	S.
2,000	4.4	SW	8.47	3.1	SSW	10.02	4.6	SSE
3,000			9.20	−3.0	SSW			

A kite flight to an exceptionally high altitude, reaching 6,855 meters above ground (6,996 M. S. L.) was made at Groesbeck on the 11th, in front of a moderate HIGH. This exceeded all previous records for altitude above ground made in this country, although higher altitudes above sea level had previously been reached here and elsewhere. The temperature record of this flight shows a practically isothermal state to 1,500 meters, and an almost uninterrupted decrease at a uniform lapse rate thereafter to the top. Winds backed gradually from northwest on the ground to west in the upper levels.

The principal instance of deep easterly winds over continental regions occurred over Ellendale on the 4th, when winds varying from east-southeast to north-northeast prevailed to 5,000 meters. On this date Ellendale lay in the western limb of an extensive high pressure area with its axis east-west over the middle Northern States and adjoining Canadian Provinces.

[1] An alternative interpretation of the evidence of the kite flights at Broken Arrow is offered, as follows: The fall in temperature from the 3d to the 4th may have been and probably was due to mixing of the lower air strata, as pointed out by Shaw (Meteorology Part IV, pp. 34–35). This mixing would tend to produce an adiabatic temperature distribution with an inversion above and this is precisely what happened on the 4th.—ED.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during December, 1924*

TEMPERATURES (° C.)

Altitude m. s. l. (m.)	Broken Arrow, Okla. (233m.)		Drexel, Nebr. (396m.)		Due West, S. C. (217m.)		Ellendale, N. Dak. (444m.)		Groesbeck, Tex. (141m.)		Royal Center, Ind. (225m.)	
	Mean	Departure from 7-yr. mean	Mean	Departure from 10-yr. mean	Mean	Departure from 4-yr. mean	Mean	Departure from 7-yr. mean	Mean	Departure from 7-yr. mean	Mean	Departure from 7-yr. mean
Surface	2.0	−3.1	−9.5	−5.2	9.2	−0.1	−14.2	−5.6	8.5	−1.6	−4.2	−3.5
250	1.9	−3.1			9.2	0.0			8.0	−1.9	−4.4	−3.0
500	1.7	−2.7	−9.6	−5.4	9.7	+0.8	−14.3	−5.8	6.7	−2.7	−6.4	−4.1
750	1.7	−2.6	−9.8	−6.1	9.7	+1.1	−14.1	−6.5	6.7	−2.5	−6.8	−4.0
1,000	2.7	−2.2	−8.7	−5.9	9.2	+1.0	−12.9	−6.3	8.0	−1.2	−6.5	−3.0
1,250	3.1	−2.0	−8.0	−5.7	8.5	+0.9	−12.4	−6.3	7.9	−0.9	−6.5	−3.6
1,500	3.2	−1.6	−7.6	−5.1	7.6	+0.9	−12.2	−6.0	7.5	−0.7	−6.3	−3.2
2,000	2.4	−1.0	−7.8	−3.9	5.7	+0.7	−12.2	−4.9	6.0	−0.6	−7.8	−3.3
2,500	0.0	−1.2	−9.7	−3.5	3.4	+0.3	−13.0	−3.6	3.5	−1.0	−8.6	−2.3
3,000	−2.2	−0.9	−11.2	−2.6	1.7	+0.8	−15.2	−2.8	1.0	−1.1	−10.3	−1.7
3,500	−4.4	−0.6	−13.3	−2.2	−1.4	0.0	−17.2	−2.0	0.8	+1.3	−13.1	−1.7
4,000	−6.5	0.0	−15.9	−2.1	−4.2	+0.3	−20.1	−2.0	−1.8	+1.4	−16.0	−1.4
4,500	−8.7	+0.6	−18.6	−1.9	−6.8	+0.7	−22.4	−1.9	−3.2	+2.2		
5,000			−21.0	−1.7					−6.5	+1.6		

RELATIVE HUMIDITY (%)

Surface	70	−1	79	+1	72	−2	80	−1	73	−2	81	+1
250	70	−1			71	−2			72	−1	81	+1
500	66	+1	77	+3	63	−5	80	+1	73	+4	80	+4
750	64	+4	73	+6	60	−5	77	+5	67	+3	78	+7
1,000	60	+7	69	+8	58	−5	72	+6	55	−2	71	+6
1,250	54	+7	68	+11	53	−8	68	+7	50	−2	65	+6
1,500	49	+6	67	+12	54	−5	66	+8	46	−2	63	+8
2,000	43	+5	66	+14	52	−3	63	+8	44	+4	64	+12
2,500	42	+5	69	+16	51	+1	62	+7	46	+10	66	+14
3,000	42	+4	70	+17	43	−2	58	+3	40	+7	65	+13
3,500	40	+2	71	+18	50	+4	52	−3	11	−19	58	+4
4,000	35	−2	68	+15	47	0	52	−2	6	−23	52	−2
4,500	35	−2	67	+13	41	−4	52	+3	1	−27		
5,000			66	+12					1	−27		

VAPOR PRESSURE (*mb.*)

Surface	5.84	−0.86	2.68	−1.02	9.41	+0.01	1.95	−0.89	9.99	−0.13	4.08	−0.69
250	5.80	−0.84			9.38	+0.08			9.58	−0.19	4.01	−0.15
500	5.56	−0.31	2.58	−0.95	8.96	+0.40	1.91	−0.89	8.84	−0.10	3.46	−0.12
750	5.35	+0.06	2.37	−0.90	8.22	+0.24	1.79	−0.85	7.97	−0.16	3.24	+0.07
1,000	5.21	+0.51	2.38	−0.71	7.48	+0.12	1.79	−0.71	6.95	−0.21	2.91	+0.10
1,250	4.62	+0.46	2.44	−0.50	6.86	+0.09	1.74	−0.64	6.00	−0.30	2.56	+0.09
1,500	4.24	+0.51	2.42	−0.34	6.24	+0.08	1.69	−0.53	5.15	−0.30	2.46	+0.24
2,000	3.46	+0.46	2.38	+0.02	5.06	+0.05	1.55	−0.33	4.19	+0.23	2.31	+0.53
2,500	2.86	+0.37	2.17	+0.13	4.30	+0.30	1.43	−0.16	3.37	+0.38	2.28	+0.83
3,000	2.32	+0.18	1.97	+0.25	3.15	−0.08	1.23	−0.05	2.10	−0.22	2.05	+0.90
3,500	1.89	+0.06	1.74	+0.31	2.69	−0.14	1.01	+0.01	0.21	−1.48	1.35	+0.42
4,000	1.46	−0.10	1.51	+0.37	1.61	−0.59	0.85	+0.03	0.01	−1.36	0.86	+0.25
4,500	1.18	−0.20	1.45	+0.57	0.61	−0.90	0.81	+0.21	0.01	−1.12		
5,000			1.38	+0.70					0.01	−0.94		

TABLE 2.—*Free-air resultant winds (m. p. s.) during December, 1924*

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233 m.)				Drexel, Nebr. (396 m.)				Due West, S. C. (217 m.)				Ellendale, N. Dak. (444 m.)				Groesbeck, Tex. (141 m.)				Royal Center, Ind. (225 m.)			
	Mean		7-year mean		Mean		10-year mean		Mean		4-year mean		Mean		7-year mean		Mean		7-year mean		Mean		7-year mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 69°W.	0.9	S. 52°W.	1.0	N. 28°W.	1.0	W.	1.1	S. 64°W.	1.3	S. 57°W.	1.3	N. 50°W.	4.4	N. 54°W.	3.4	N. 52°W.	0.9	N. 85°W.	1.1	S. 55°W.	2.7	S. 51°W.	2.2
250	S. 61°W.	1.0	S. 45°W.	1.3					S. 61°W.	1.7	S. 55°W.	1.6					N. 41°W.	0.8	S. 69°W.	1.4	S. 50°W.	3.0	S. 50°W.	2.5
500	S. 40°W.	3.3	S. 46°W.	3.2	N. 39°W.	1.4	N. 87°W.	1.9	S. 55°W.	4.4	S. 62°W.	3.6	N. 54°W.	4.9	N. 60°W.	3.8	S. 51°W.	0.7	S. 55°W.	2.8	S. 60°W.	6.2	S. 57°W.	5.4
750	S. 50°W.	4.2	S. 50°W.	4.1	N. 64°W.	1.8	N. 77°W.	3.6	S. 57°W.	6.6	S. 66°W.	5.4	N. 53°W.	7.7	N. 59°W.	6.0	S. 40°W.	1.0	S. 53°W.	4.0	S. 71°W.	8.4	S. 67°W.	7.1
1,000	S. 63°W.	5.1	S. 64°W.	4.7	N. 68°W.	3.3	N. 76°W.	4.8	S. 63°W.	8.6	S. 72°W.	7.0	N. 49°W.	8.9	N. 57°W.	7.2	S. 34°W.	3.7	S. 55°W.	5.4	S. 80°W.	9.7	S. 78°W.	8.2
1,250	S. 72°W.	6.1	S. 76°W.	5.1	N. 81°W.	5.4	N. 76°W.	5.6	S. 63°W.	11.4	S. 72°W.	8.5	N. 53°W.	8.9	N. 57°W.	7.8	S. 45°W.	6.0	S. 61°W.	6.5	S. 80°W.	10.8	S. 82°W.	10.0
1,500	S. 71°W.	7.8	S. 79°W.	5.8	N. 83°W.	7.3	N. 78°W.	7.0	S. 75°W.	12.9	S. 81°W.	9.6	N. 53°W.	9.7	N. 58°W.	8.9	S. 53°W.	9.3	S. 64°W.	7.5	S. 78°W.	11.8	S. 86°W.	11.0
2,000	S. 70°W.	9.9	S. 81°W.	7.3	N. 83°W.	10.6	N. 80°W.	9.0	S. 74°W.	14.4	S. 83°W.	10.9	N. 54°W.	12.2	N. 60°W.	10.3	S. 56°W.	10.5	S. 69°W.	8.6	N. 85°W.	13.5	N. 88°W.	12.6
2,500	S. 69°W.	11.0	S. 86°W.	9.5	N. 78°W.	14.0	N. 78°W.	11.5	S. 83°W.	13.7	W.	12.1	N. 57°W.	14.9	N. 63°W.	12.2	S. 54°W.	12.8	S. 74°W.	9.8	N. 85°W.	19.8	N. 86°W.	14.2
3,000	S. 71°W.	11.6	S. 88°W.	11.1	N. 74°W.	19.0	N. 79°W.	13.9	S. 89°W.	15.3	N. 87°W.	14.3	N. 60°W.	17.1	N. 66°W.	13.6	S. 77°W.	13.1	S. 74°W.	11.6	N. 81°W.	21.2	S. 88°W.	14.3
3,500	S. 88°W.	13.1	S. 88°W.	12.0	N. 70°W.	19.0	N. 82°W.	15.4	S. 81°W.	18.8	S. 88°W.	14.7	N. 56°W.	16.4	N. 72°W.	15.0	N. 88°W.	10.2	S. 75°W.	12.0	S. 80°W.	18.2	S. 83°W.	11.9
4,000	N. 68°W.	14.3	N. 83°W.	11.1	N. 83°W.	20.1	N. 85°W.	16.8	W.	17.0	N. 88°W.	13.2	N. 60°W.	13.1	N. 74°W.	14.5	N. 68°W.	10.0	S. 76°W.	11.4	S. 67°W.	19.1	S. 72°W.	13.7
4,500	N. 79°W.	14.8	N. 79°W.	12.9	S. 78°W.	20.2	N. 74°W.	17.7	W.	18.0	N. 88°W.	14.8	N. 67°W.	13.0	S. 85°W.	15.0	N. 68°W.	9.0	N. 88°W.	11.9				
5,000	N. 67°W.	18.0	N. 81°W.	15.6	S. 77°W.	23.2	N. 83°W.	18.6			N. 67°W.	12.6	N. 68°W.	15.0	N. 86°W.	14.8	N. 68°W.	11.1	N. 82°W.	14.4				

THE WEATHER ELEMENTS

By P. C. DAY, In Charge of Division

PRESSURE AND WINDS

The distribution of pressure during the month favored weather phases not common to the first month of winter. These were brought about mainly by the frequent presence of anticyclonic areas over the southern and southeastern districts, and by cyclones of more or less intensity over the central and northern districts, during the first half of the month, and by anticyclones of unusual strength over the Northwest and West during the latter half.

The month as a whole showed pressure averages above the normal in all parts of the country, with unusual excesses over the Northwest, the latter being brought about largely by the extensive anticyclones moving from Alaska and the Canadian Northwest into that region from about the 15th onward.

The frequent extension westward of the North Atlantic high pressure area into the Southeastern States and the general trend of the moderate cyclones over the central and northern districts favored moderate winter weather in nearly all districts until near the middle of the month.

About the 12th pressure began to rise in central and eastern Alaska and by the 15th had reached the unusual sea-level value of 31 inches at Eagle, probably, with a single exception, the highest pressure ever observed at that place. Attending this anticyclone the first extensive cold wave of the season overspread Alaska and advanced southward over the Canadian Northwest, reaching the northern limits of the United States on the morning of the 15th, from which date until near the end of the month abnormally high pressure attended by unusual cold persisted almost constantly in the western districts.

During the period mentioned above the sea-level pressures were frequently above 31 inches, a number of stations reporting the highest pressures ever observed, and severe cold prevailed over nearly all parts of the country, but particularly in the Northwest and West where, in many instances, it was the longest and most severe period of cold ever experienced.

The cyclones during the month were somewhat fewer than usually experienced in the first month of winter, except over portions of the interior where they prevailed frequently during the first half though they were mainly of a mild type. During the latter part of the month the cyclones moved, as a rule, over paths unusually far to the southward being forced into these by the high pressure over central and northern districts.

Compared with the pressure distribution during the preceding month the averages for December exceeded those for November over all parts of the country. While this is usually to be expected over all districts save the extreme Northeast and Northwest, still the differences are usually far less than those shown between these two months in 1924.

In the absence of important cyclones the winds were not frequently high although a few stations reported average velocities equal to or in excess of any previous records for December, and Seattle, Wash., reported the highest velocity ever known at that place on the 11th. The prevailing wind directions are shown on Chart VI.

TEMPERATURE

The important feature of the weather for the month was the sudden change from the mild winter temperatures that prevailed in most portions of the country during the first half of the month, to the severe cold that set in over the Northwest on the 15th, and after a few days overspread nearly the entire country.

Slightly preceding the advent of the cold wave some unusually high temperatures prevailed at points in the northern Rocky Mountain region, notably at Helena, Mont., where a temperature of 63° was recorded on the 14th and on the next day it had fallen to 16° below zero, a change of 79° in 24 hours. This was probably among the greatest 24-hour variations of temperature of record. Similar changes were reported at other nearby stations.

As the cold wave lingered a few days over the western districts, some unusually high temperatures were observed over the Gulf and South Atlantic States where, from the 16th to 19th, many points had the highest December temperatures ever reported.

By the end of the second decade the cold wave had advanced into the central and southern districts, reaching the extreme southern part of Texas by the morning of the 20th with temperatures several degrees below freezing and continuing below that point for nearly two days. The average daily temperatures along the southern Texas coast on the 20th and 21st were locally the lowest ever observed. This cold wave diminished somewhat in severity as it moved eastward and did not materially threaten the important fruit and trucking districts of the Southeast.

With the exception of short intervals the barometric pressure continued high over the middle and western districts throughout nearly the entire third decade of the month and unusually severe cold was experienced in that region. In fact over the far Northwest the period from the 16th to 27th was almost continuously colder than normal, usually to a marked extent, and the period as a whole was the coldest ever experienced in that region. At Portland, Oreg., the temperature was continuously below freezing from the early morning of the 16th to the late evening of the 27th, the longest period of time with such temperatures ever experienced at that point, although lower temperatures had been experienced for short periods. Similar conditions prevailed over much of the country from the Mississippi River westward, and numerous points at various times during that period had the lowest December temperatures ever recorded.

Warmer weather set in over the Northwest during the last few days of the month, and at the close moderate winter temperature prevailed in most districts.

The periods of highest temperatures were mainly during the first half, save over the southern portions of the central valleys where the highest temperatures were not recorded until about the 16th to 18th.

The lowest temperatures were mainly after the end of the second decade, although a few States in the Southeast had the minimum temperatures for the month on the 2d, and the extreme cold for the month in the northern Rocky Mountain regions and portions of the Pacific States was experienced on the 18th and 19th, at which time minimum readings 40° to nearly 60° below zero were recorded, the lowest observed −59° being reported from a point in the mountains of Wyoming. At places in California and to the northward the minimum temperatures about this time were the absolute lowest for any month. In the districts from the Mississippi Valley eastward the lowest temperatures were mainly during the last decade.

The mean temperature for the month was below normal over all parts of the country save over the Florida Peninsula and from southern Louisiana northeastward to the Chesapeake Bay region. Over the interior valleys, the

Northwest, and far West, the averages ranged from 6° to 10° or more below normal, and at many points it was the coldest December experienced in more than 50 years. Despite the severe cold over most districts, the Southeastern States had more moderate temperatures, and in southern Florida it was among the warmest Decembers of record.

PRECIPITATION

Unlike the several months preceding, December, 1924, had more than the normal precipitation over the greater part of the country, the excesses being large in the eastern Gulf and South Atlantic States and portions of the Ohio Valley. Elsewhere the variations above or below the normal were mainly unimportant, although in portions of New England the monthly falls were among the least of record and the year closed with large deficiencies. The distribution through the month was mainly satisfactory to farming and other operations, and the severe drought that had prevailed in portions of Alabama, Mississippi, Kentucky, and locally in adjacent States was broken. More rain was needed, however, in central and western Texas.

Some unusually damaging ice storms occurred, notably on the 4th and 5th, when a heavy accumulation of ice formed over an extensive region from western Kansas northeastward over portions of Nebraska and into central Iowa. Extensive damage resulted to overhead wire systems, orchards, etc., particularly in central Iowa, where it was reported as one of the worst of its character ever experienced in the State.

From the 17th to 19th, just preceding the severe cold wave, an ice storm of great extent and unusual severity extended from central Oklahoma and eastern Kansas northeastward over portions of Missouri, Illinois, and northern Indiana to southern Michigan. In portions of this area, particularly in central and southern Missouri, and central Illinois, ice formed on all exposed objects from 2 to 4 inches in thickness, and the damage resulting from this unusual coating on trees of all kinds and overhead wire systems was enormous. Trees were stripped of their branches and frequently entirely broken down, while poles bearing overhead wires were broken by the thousands, and great damage and interruption to transportation and communication interests resulted. Details concerning this storm appear elsewhere in this issue.

An unusual ice storm occurred over southeastern Texas from the 18th to 20th, particularly near the coast, likewise just in advance of the severe cold moving southeasterly, and in addition to damage to trees and wires much loss resulted to unprotected cattle from exposure to the ice storm and the severe cold immediately following.

SNOWFALL

Except from Louisiana and southern Arkansas eastward to the coast, and in portions of the Carolinas, Virginia, southern Arizona and the coast districts of California, snow fell at some period during the month in all parts of the country. In Texas snow occurred to the extreme southern part of the State, amounts of 1 inch or more being reported from the lower Rio Grande Valley. Also in California snow fell nearly to the southern limits of the State.

The monthly falls were generally above normal in the Rocky Mountain system from northern New Mexico to the Canadian boundary, and likewise over Utah and adjacent portions of the Plateau region.

In the mountains of California there was mainly less snowfall than normal, particularly in the northern portions, and but little remained on the ground at the end of the month, though it was well packed and had a good water content.

East of the Rocky Mountains there was some heavy snow at the end of the month in Kansas and portions of adjacent States, but elsewhere the fall was usually moderate to light, being particularly light in the eastern mountains and over New York and New England, where there was not sufficient for the usual lumbering operations.

Ice of good quality was available for harvest in all western districts where it is usually stored and was acquiring considerable thickness in eastern districts as the month closed.

RELATIVE HUMIDITY

Over a wide area from the lower Mississippi Valley northeastward to and including New England the relative humidity was, as a rule, materially less than normal, despite the fact that the precipitation over portions of the region was well above normal and much cloudiness existed. Over the remainder of the country there were no large areas having important departures either above or below normal though in the Rocky Mountain and Plateau regions the averages for the month were mainly higher than normal, while material deficiencies were reported from the far Northwest.

SEVERE LOCAL HAIL AND WIND STORMS, DECEMBER, 1924

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Iowa, Nebraska, Kansas, southern Wisconsin, northern Illinois and lower Michigan.	3–5				$2,000,000	Ice and sleet	Damage principally to light, power, telephone and telegraph lines. Traffic demoralized. Iowa and Nebraska sustain heaviest losses.	Telegraph Herald (Dubuque) Iowa. Wichita Beacon (Kans.). Official, U. S. Weather Bureau.
Bay Springs, Miss.	4	9 p. m.			10,000	Tornadic wind	Character of damage not reported. Two persons seriously injured.	Do.
Trigg, Christian, and Todd Counties, Ky.	7				25,000	Wind	Extensive damage to farm buildings.	Do.
Beedeville, Ark.	7		150	3		Tornado	Several houses and barns destroyed; woodland laid waste for a distance of 1½ miles. One person injured.	Do.
Pine Bluff, Ark.	7				6,000	Electrical	Large barn burned, destroying about 2,000 tons of hay.	Do.
Eureka Springs, Ark. (9 miles west of).	7	Noon to 12.40 p. m.				Moderate hail	Slight damage.	Do.
Helena, Ark.	7	2.30 p. m.				Rain, wind and hail.	Minor damage.	Do.
Morrillton, Ark.	7	3.20 p. m.				do	Several thousand dollars damage reported.	Do.
Grannsi, Ark.	7	3.30 p. m.				Heavy hail	Slight damage.	Do.
Hot Springs, Ark.	7	3.30 p. m.				Rain, wind and hail.	Considerable damage.	Do.
Searcy, Ark.	7	4 p. m.			12,000	do	Property damage considerable.	Do.
Danville, Ark.	7	4.30 p. m.				Heavy hail	Slight damage.	Do.
Stuttgart, Ark.	7					Wind and hail	do	Do.
Benton, Ark.	7					Wind, rain, and hail.	Fences, telephone and telegraph poles, and trees damaged.	Do.
Perry, Ark.	7					Hail	Minor damage reported.	Do.
Beebe, Ark.	7				2,500	Straight wind	Character of damage not reported.	Do.
Tennessee (northwestern counties of).	7			2	250,000	Strong winds	Heavy property damage including the destruction of tobacco barns and contents in Dickinson, Montgomery, and Stewart Counties. 15 persons injured.	Do.
Montana (north and west-central part of).	12	Midnight to 8 a. m.				High wind	Property damage can not be estimated. Windows broken, garages and other light structures demolished, poles blown down, and hay stacks blown away.	Do.
Grand Haven, Mich.	13					Gale	Local steamers kept in port. Minor damage about the city.	Do.
Lincoln and Flathead counties, Mont.	15					High wind and blizzard.	500 forest trees blown down; long-distance wires out of commission; light and water systems crippled. Great suffering in many localities.	
Middle and west-central States.	16–19					Ice and sleet	Extremely heavy damage, principally to overhead wire systems. Many branches broken; traffic demoralized; numerous accidents due to slippery streets and sidewalks. Damage estimated at more than $5,000,000 in Illinois alone.	Do.
Oklahoma.	17–18				500,000	Sleet and snow	Railway and street traffic badly crippled; much damage to overhead wire stems.	Do.
New York (central part of).	18					Ice	Amount of damage not reported.	Do.
Fort Smith, Ark.	18	2.48 p. m.				Thunderstorm	Steam turbine at power plant damaged by lightning, causing lights to be extinguished.	
Fort Worth, Tex. (and vicinity).	19	A. m.				Sleet and snow	Traffic impeded; telegraph service crippled; several accidents due to condition of thoroughfares.	Do.
Corpus Christi, Tex., and surrounding counties.	19–21					Ice and sleet	Trees, flowers, and citrus fruit trees killed; wires broken; cattle suffer severely; many being killed by the intense cold.	Do.
Red Bluff, Calif.	20–21					Snow	Considerable damage to overhead wires; limbs of citrus and evergreen trees broken.	Do.
California (southern part of).	24					High winds	Citrus fruits injured. Small shipping harassed at San Pedro.	Official, U. S. Weather Bureau. Tribune (Pocatello, Idaho).
Brownsville, Tex.	25–26					Ice	No damage reported.	Official, U. S. Weather Bureau.
Grand Haven, Mich.	26					Wind, ice and heavy seas.	Car ferry No. 19 driven ashore. No other damage reported.	Do.
Boise, Idaho.	29–30					Ice	Limbs and wires broken by weight of ice; sidewalks and streets dangerous.	Do.

STORMS AND WEATHER WARNINGS

WASHINGTON FORECAST DISTRICT

Storm warnings.—Storm warnings were issued during the month in connection with seven storms and were almost entirely for the region from Cape Hatteras northward. Warnings were displayed at all stations from Delaware Breakwater to Eastport, Me., for six of the seven storms, the only exception being that of the 20th–21st, when warnings were ordered for the coast south of Cape Hatteras as far as Jacksonville, Fla. The only warnings issued for the east Gulf coast were those of the 20th, for the Mississippi, Alabama, and northwest Florida coasts.

There were really no severe storms along the Atlantic seaboard during December, although the barometer fell to 29.16 inches at Boston and 28.98 inches at Montreal on the 13th. The maximum wind velocity reported during this storm was 60 miles an hour from the northwest at New York City. This velocity is quite moderate for a depression of such intensity. A much higher wind would undoubtedly have occurred if there had been an area of high pressure of considerable strength either in front of or behind this storm. This not being the case, the pressure gradient resulting from the disturbance itself was insufficient to cause winds of greater velocity.

In addition to the storm warnings there were four dates during the month on which small craft warnings were issued for a part of the Atlantic or the east Gulf coast.

Cold-wave warnings.—There were two widespread cold waves in the Washington forecast district during the latter half of the month. The first reached the lower Ohio and lower Mississippi Valleys on the 19th and the Atlantic coast on the 20th; and the second overspread the lower Lake region, the Ohio Valley, western Tennessee, the interior of the east Gulf States, and the North Atlantic States during the 27th–28th. The change to colder weather did not reach the proportions of a cold wave in the Atlantic States south of eastern Pennsylvania. Cold-wave warnings were issued in advance of

these two more or less general cold waves and also for limited areas on the 8th, 13th, 24th, and 25th.

Warnings for frost and freezing temperature were issued for portions of the east Gulf and South Atlantic States on 12 days during the month. While these warnings included extreme northern Florida eight times, the only forecast of frost for central Florida was that of the 1st. Bartow reported light frost on the morning of the 2d, the only frost during the month in that section. The atmospheric pressure remained relatively high over the Florida Peninsula and over the ocean to the eastward throughout the period of advance of the two widespread cold waves from the Northwest. Consequently, no damaging temperature was experienced in the Florida Peninsula.—*C. L. Mitchell.*

CHICAGO FORECAST DISTRICT

The monthly mean temperature was far below the seasonal normal over practically the entire forecast district. The greatest departures were −12.3° at Duluth, Minn., and −11.6° at Havre, Mont., and the smallest departure was −2.6° at Cairo, Ill.

The precipitation was below the monthly normal over the Upper Lake region, but in nearly all other sections it was above, and markedly so in the lower Ohio and lower Missouri Valleys.

Cold-wave warnings.—Although the average monthly temperature was very low, the weather was, nevertheless, fairly mild during the first half, and the cold waves during that period were local and fleeting. It was not until the night of the 14th that the front of the first cold wave, which had moved southeastward from Alaska, reached Alberta. This steadily increased in energy, with not only falling temperature but increasing atmospheric pressure. The full force of the cold wave was not felt to the eastern limits of the district until the 19th and 20th. The pressure exceeded the December record at several stations in the district, and the cold was more severe than any previously experienced in December for many years. Warnings were issued well in advance of the fall in temperature, and all interests throughout the district notified.

The cold continued in most sections until near the close of the month, aside from temporary relief on two or three days. There was marked redevelopment in the Northwest on the 26th, and in consequence, additional cold-wave warnings were necessary for the eastern portion of the forecast district.

Livestock warnings.—Warnings were issued on the 14th of the month to livestock interests in Montana, the Dakotas, Wyoming, and Nebraska. Additional messages were sent to the southern portion of this area on December 15 and 16, and on the 17th the warnings were extended into Kansas, so that the cattle interests had advice well in advance of the great cold wave and strong northerly winds which accompanied it.

Storm warnings.—Storm warnings were issued for the Great Lakes during the month from time to time, when occasion demanded, until the close of regular navigation on the 16th. The principal storm occurred on the 13th, due to the rapid deepening of a depression in Ontario and the development of a high in Manitoba. On the morning of the 12th a forecast for "fresh to strong winds with rain or snow" was made for the Upper Lakes and "fresh winds" for the Lower Lakes, and in the evening northwest storm warnings were ordered on Lake Superior, it being thought that warnings might be issued on the morning of the 13th sufficiently early for the rest of the region. However, by daybreak the storm was being felt in full force over Lake Michigan, and later in the day over Lake Huron and the Lower Lakes. Storm warnings were then, of course, flying at all Lake stations, although, obviously, too late to be of any service on Lakes Michigan and Huron. However, because of the lateness of the season, most of the vessels had made their last trip and had reached winter quarters: and, fortunately, so far as known, no losses were sustained.

Special attention was given to the shippers of perishable goods in all directions during the extreme winter conditions, as a part of the regular advisory service maintained for the benefit of fruit shippers in the north Pacific States. Messages were sent to three exchanges every Monday morning, covering, as far as practicable, the temperature conditions for the ensuing week for the northwestern portion of the Chicago district. These advices had, for the most part, a high degree of verification, and it is believed that no loss whatever was sustained by these shippers.—*H. J. Cox.*

NEW ORLEANS FORECAST DISTRICT

After the first week, areas of high pressure were dominant and in some instances were attended by severe cold.

Cold-wave warnings were issued during the afternoon of the 3d for the northwestern portion of the district except the northern portion of West Texas. Temperatures below freezing occurred on the morning of the 5th but were not low enough to verify the cold-wave warnings. In this instance the principal crest of the area of high pressure moved eastward, and the western extension following the LOW diminished in intensity.

A cold-wave warning was issued for parts of central and southwestern Texas on the ninth, after the receipt of special observations, but failed of verification, conditions proving to be less intense than was expected, with cloudy weather ensuing.

Warnings were issued well in advance of a slow moving but severe cold wave which reached the northwestern portion of the district on the 17th and extended to the Texas coast on the 19th and to the Louisiana coast on the 20th. The area of high pressure in this instance was unusually large and was preceded by a well-defined area of low pressure which moved slowly southward over the Rocky Mountain region and the Southwestern States. The cold wave was attended by considerable snow and sleet, with glaze in some localities. Stockmen received early advices of the severe conditions. Temperatures of 24° to 30° were predicted on two successive days for the lower Rio Grande Valley and temperatures occurred as forecast, with a minimum of 26° at Brownsville, Tex.

While temperatures were still low in most sections of the district a large northwestern HIGH and a southwestern LOW attained marked development on the 23d and a cold wave occurred as the high moved southward, reaching the Texas coast Christmas eve and extending to the southeastern coast of Louisiana during the night of the 24th–25th. Timely cold-wave and temperature warnings and warnings for stockmen were issued.

Cold-wave and livestock warnings were issued for the district, except the southwestern portion of West Texas, in timely advance of a large area of high pressure, which moved southeastward from Alberta on the 26th–27th; but after reaching the lower Missouri Valley, the crest of the area of high pressure moved eastward. Freezing temperatures did not reach the coast, but there was a cold wave as forecast for the interior sections of the district, with temperatures below zero in central Oklahoma and zero to 14° above in Arkansas.

On the morning of the 31st, a large area of high pressure, crested near Winnipeg, Manitoba, occupied the northern half of the country and pressure was low over the upper Rio Grande Valley. Cold-wave warnings were issued for Arkansas and were extended, on special observations, over southern Oklahoma, the northern and western portions of East Texas, and the southeastern portion of West Texas. The warning was generally verified. A cold wave occurred also in the northern portion of West Texas, for which special temperature and livestock warnings had been issued, the temperatures predicted being only slightly higher than the temperatures that occurred.

Northwest storm warnings were issued for the Texas coast at 3 p. m. on the 9th. Northerly winds, closely approximating the verifying velocity occurred.

Warnings for the norther that reached the Texas coast on the 19th were issued at 8.40 p. m. on the 18th and were extended the next morning along the Louisiana coast. For similar conditions on the 24th, northwest storm warnings were issued for the Texas coast at 9 p. m. of the 23d and small-craft warnings were displayed on the Louisiana coast the next morning. Small-craft warnings were displayed also on the Texas coast on the 3d and 29th.

Warnings for northerly gales at Tampico, Mexico, were issued on the 19th and 24th.

In addition to the cold-wave warnings, frost or freezing temperature warnings, mostly for the coast sections, were issued on the 1st, 8th, 9th, 10th, 11th, 21st, 25th, 26th, 27th, and 28th; these warnings were generally verified.—*R. A. Dyke.*

DENVER FORECAST DISTRICT

The month was cold and stormy, with frequent disturbances advancing southeastward across the district, followed by HIGHS of remarkable intensity. The most notable storm moved southeastward from eastern Washington during the 15th, taking the place of an area of high pressure that had occupied the Plateau region for about a week, while another HIGH of unusual strength covered the northeastern Rocky Mountain slope. The LOW decreased rapidly in intensity during the 17th and reached New Mexico on the night of that date. The area of high pressure overspread the entire Rocky Mountain region by the 19th, with its crest over western Wyoming, where the pressure increased to more than 31.2 inches, and temperatures below zero extended to southern Colorado and north-central Arizona on the morning of that date.

Warnings of cold waves were issued as conditions seemed to require on the dates and for the States and parts of States as shown in the exhibit below. These warnings were generally verified.

Cold-wave warnings, Denver district, December, 1924

Dates	Character of cold wave	Places
Dec. 6	Moderate	Arizona (except extreme southwest portion), Colorado, Utah (eastern and southern).
15	do	Colorado (eastern and central).
16	Severe	Colorado (eastern and central), northeast and extreme southeast New Mexico.
16	Moderate	Extreme west Colorado, northwest New Mexico, northeast Arizona, and Utah.
17	do	West Colorado, north New Mexico, east Utah.
17	Severe	New Mexico.
18	do	West Colorado and north New Mexico.
23	Moderate	West Colorado, north and west New Mexico, east Arizona, and south Utah.
26	Severe (?)	Colorado (east and central).
27	do. (?)	Colorado (east), and New Mexico (northeast).
30	Moderate	Colorado (northeast and southeast), Utah (southwest).
31	do	Colorado (west), New Mexico (north and extreme east), Arizona (east), Utah (southeast).

Livestock warnings were issued on the 6th for Colorado, Arizona, except the extreme southwest portion, and Utah; on the 23d for western Colorado, northern and western New Mexico, eastern Arizona and southern Utah; on the 30th for eastern Colorado and southwestern Utah. The warnings were generally justified, except those for southern Arizona on the 6th.

The followings warnings of frost and freezing temperature were issued for southern Arizona: 3d, 4th, 7th, 9th, 10th, 11th, 17th, 20th, and 21st, frost south-central and southeast portions; 18th and 31st, frost south, freezing tempreature south-central and southeast portions; 19th, freezing temperature south-central, frost extreme southwest portions; 23d, 26th, and 29th, frost south portion; 24th, 25th, and 27th, frost extreme southwest, freezing temperature south-central and southeast portions. These warnings were generally verified.—*J. M. Sherier.*

SAN FRANCISCO FORECAST DISTRICT

Abnormal weather conditions prevailed in the San Francisco forecast district during the month of December, 1924. Marked changes occurred in rapid succession, especially from the 8th to the 26th, inclusive. To understand the cause of this period of extraordinary weather, it is necessary to examine daily graphs of both pressure and temperature at stations in Alaska and at Honolulu. A study of these will disclose the fact that there was a constantly falling pressure at Honolulu from the 5th to a minimum on the 15th, and a gradual rise thereafter until the close of the month. There was a rise to above normal pressure over Bering Sea at the end of November, and the pressure continued above normal over that area until the 25th. Over Alaska proper the pressure was normal during the first 10 days of the month, decidedly above normal from the 11th until the 27th, and below normal thereafter. The peaks of highest pressure, which approximated 31 inches, occurred at most Alaska stations on the 14th and 15th and again on the 20th and 21st, over British Columbia on the 23d, and over Idaho on the 25th. The graphs of temperature show a decided change to lower temperatures at Alaska stations to a minimum for the month between the 11th and 15th. This polar air made its appearance over British Columbia on the 15th and moved thence southward, enveloping the whole Pacific slope during the following 48 hours. Temperatures continued decidedly below normal thereafter on the Pacific slope until after the 27th, when a marked rise overspread this region.

The following special forecasts and warnings were issued during the month: (*a*) On the 5th, for heavy snows in the Sierra Nevada during the next 24 hours; (*b*) on the 15th, livestock warnings were issued for eastern Washington, eastern Oregon, Idaho, and Nevada for snow, strong north winds, and much colder for the next two or three days; and (*c*) cold-wave warnings issued for the same section for temperatures much below freezing during the next 36 hours, and for freezing temperatures in northern and central California in 48 hours; (*d*) cold-wave warnings were issued on the 16th, in eastern Oregon, southern Idaho and Nevada for temperatures of zero or below in the next 36 hours; and (*e*) warnings in the citrus belt of southern California for much lower temperature for the next three days, when firing would be necessary; (*f*) on the 19th, special warnings in California, also given to the press associations, for increasing cloudiness with rising temperature probably followed by rain in California and snow turning to rain in Washington and Oregon in the next 24 to 36 hours; (*g*) on the 26th, a warning for unsettled

weather and higher temperatures with rain or snow in Washington and Oregon and rain in northern California within the next 36 hours, and continued fair weather with zero temperatures in Idaho and Nevada was issued and given to the press.

Storm warnings were ordered on 17 days and frost warnings issued repeatedly between the 9th and 27th. The warnings were generally timely and verified.

The record for low temperature in December, was broken at North Head, Eureka, Winnemucca, Boise, and Pocatello during the month.—*G. H. Willson.*

RIVERS AND FLOODS

By H. C. FRANKENFIELD

Inspection of the table following will disclose the fact that no floods of consequence occurred during the month of December. Those that did occur were confined mainly to some of the rivers of the Carolinas and to the Kentucky and Green Rivers of Kentucky and the Wabash River of Indiana. The heavy rains of December 7 and 8 would ordinarily have caused severe floods in the rivers of South Carolina and Kentucky, but the preceding season had been so devoid of rainfall that the soil absorbed much of the water that would ordinarily have gone into the rivers. This is especially true of the Kentucky and Green drainage areas over which the rainfall for the two days mentioned ranged from 3.5 to 8.5 inches, yet the resulting floods were only moderate and without damage of consequence. The Wabash River flood of the third decade of the month was somewhat more pronounced, although not at all dangerous. The soil was moist from the earlier rains of the month and the heavy fall from December 17 to 19 was sufficient to raise the river a few feet above flood stages, except at Lafayette, Ind., where the excess was 10.2 feet. Here also the losses were small. The remaining floods noted in the table do not need special mention.

The loss and damage resulting from the floods were virtually nothing in the Carolinas and Georgia, and only about $8,000 elsewhere, with reported savings through the warnings issued of at least an equivalent amount.

Other rivers were low as a rule. At the close of the month the Mississippi River was frozen over as far south as Hannibal, Mo., or a short distance below, while the Missouri River was frozen to a short distance below the mouth of the Kansas River. On December 29 an ice gorge formed in the Mississippi River at Turkey Island, about 55 miles below St. Louis, backing up the water above to such an extent that the river at St. Louis rose from 3.7 feet on the morning of December 29 to 11 feet at midnight December 31, with a further slow rise to 12.6 feet by January 5, 1925.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC DRAINAGE	*Feet*			*Feet*	
Roanoke, Weldon, N. C.	30	11	11	32.0	11
Santee:					
Rimini, S. C.	12	12	19	13.8	14
		25	(1)		
Ferguson, S. C.	12	12	22	13.3	15-16
		26	(1)		
Saluda:					
Pelzer, S. C.	7	10	10	7.6	10
Chappells, S. C.	14	25	25	15.2	25
Oconee, Milledgeville, Ga.	22	25	25	23.3	25

[1] Continued at end of month.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
MISSISSIPPI DRAINAGE	*Feet*			*Feet*	
Licking, Falmouth, Ky.	28	8	9	29.2	9
Kentucky:					
High Bridge, Ky.	30	9	9	31.3	9
Frankfort, Ky.	31	9	10	32.0	9
Green:					
Munfordville, Ky.	28	9	12	39.3	11
Lock No. 6, Brownsville, Ky.	30	8	12	37.2	12
Lock No. 4, Woodbury, Ky.	33	8	14	42.2	11
Lock No. 2, Rumsey, Ky.	34	13	16	35.4	15
Big Barren, Bowling Green, Ky.	20	9	10	21.0	10
Wabash:					
Lafayette, Ind.	11	19	23	21.2	21
Terre Haute, Ind.	16	20	27	19.4	24
Vincennes, Ind.	14	24	30	16.7	28
Mount Carmel, Ill.	16	28	28	16.0	28
White, West Fork:					
Noblesville, Ind.	14	20	20	14.7	20
Elliston, Ind.	19	22	24	20.4	23
Edwardsport, Ind.	15	22	26	17.4	25
Big Pigeon, Newport, Tenn.	6	9	9	6.7	9
Meramec:					
Steelville, Mo.	12	20	20	12.1	20
Pacific, Mo.	11	20	22	16.0	22
Bourbeuse, Union, Mo.	10	20	21	12.4	21
White, Batesville, Ark.	23	21	21	23.9	21
Gasconade, Arlington, Mo.	12	20	21	13.0	20
PACIFIC DRAINAGE					
Willamette, Eugene, Oreg.	10	30	(1)	14.0	30
Santiam, Jefferson, Oreg.	10	30	30	11.0	30

MEAN LAKE LEVELS DURING DECEMBER, 1924

By UNITED STATES LAKE SURVEY

[Detroit, Mich., January 5, 1925]

The following data are reported in the "Notice to Mariners" of the above date:

Data	Lakes [1]			
	Superior	Michigan and Huron	Erie	Ontario
Mean level during December, 1924:	*Feet*	*Feet*	*Feet*	*Feet*
Above mean sea level at New York	601.49	578.48	570.84	244.58
Above or below—				
Mean stage of November, 1924	−.23	−.28	−.24	−.37
Mean stage of December, 1923	−.24	−.32	−.41	+.11
Average stage for December last 10 years	−.78	−1.43	−.86	−.66
Highest recorded December stage	−1.64	−4.10	−2.69	−3.03
Lowest recorded December stage	+.29	−.32	−.02	+1.15
Average relation of the December level to:				
November level		−.2	−.1	−.2
January level		(2)	+.1	(2)

[1] Lake St. Clair's level: In December, 1924, 573.49 feet.
[2] Practically no difference.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS—DECEMBER, 1924

By J. B. KINCER

General conditions.—The outstanding features of the weather in relation to agricultural interests during December were the breaking of the widespread drought from the Mississippi Valley eastward during the first part of the month and the unusually cold weather which interrupted all outdoor operations over most of the country during the latter half. The first copious rainfall for a long time occurred over the States from the Ohio and middle Mississippi Valleys southward, and the drought, which had become the most severe of record in parts of that area, was effectually relieved. In central and east Gulf and South Atlantic districts the increased moisture facilitated plowing, while vegetation in general was favorably affected. Except for some interruption by rainfall, seasonable outdoor operations made good progress in

Southern States during the first half of the month, but heavy snow or glaze in parts of the Great Plains and upper Mississippi Valley interrupted rail and highway traffic and did considerable damage, especially to overhead wires.

During the last half of the month outdoor work was largely at a standstill from the Great Plains eastward, because of the cold and stormy weather. Fortunately a good covering of snow was deposited on grain and grass fields over the northern half of the country previously to the cold weather, but at the same time a considerable part of the central Mississippi Valley and much of the western Lake region was covered, soon after the middle of the month, with an ice sheet which persisted till the close. Damaging cold did not reach the winter trucking districts of the Southeast and no extensive harm from frost was reported from that area, though protective measures were employed in some sections. Conditions were mostly favorable for husking corn, except for some interruption by precipitation, and good progress was made in picking the remnant of the cotton crop in the northern and northwestern parts of the belt.

Small grains.—Under the influence of mild temperatures and beneficial precipitation during the first half of the month, winter wheat made satisfactory progress quite generally, though more moisture was needed in the southwestern part of the Wheat Belt. The crop showed improvement in the Ohio Valley and Great Plains States with the unfrozen soil absorbing the moisture resulting from melting snow in much of the latter area. The Middle Atlantic States and the South also reported improvement in all winter cereal crops, while conditions continued favorable in the far Northwest.

The southeastern portion of the Winter Wheat Belt was bare of snow when the cold weather set in soon after the middle of the month, and the sudden change from growing conditions to a severe freeze was rather hard on the succulent plants, and at the same time there was apprehension as to possible damage by reason of the ice-covered fields in Missouri, west-central Illinois, and parts of the western Lake region. In other parts of the Wheat Belt the fields were generally well protected by snow. There was a good covering also over Rocky Mountain districts and the far Northwest, but the cold was unfavorable for winter oats in the South.

Ranges, pastures, and livestock.—Rainfall early in the month improved pastures and ranges in the far West, the Southwest, and generally in the Southern States, while the open condition of the range permitted much grazing in the northern Great Plains. The sudden change to cold about the middle of the month, however, was hard on livestock over the western half of the country, and considerable suffering and shrinkage were reported, though no material losses occurred, except in parts of Texas where sleet was heavy. Much feeding was necessary and widespread protective measures were employed. Snowfall was beneficial in replenishing the water supply over the northwestern Great Plains and some improvement resulted in the southwestern range by precipitation near the close of the month.

Miscellaneous crops.—In the South Atlantic and east Gulf States winter truck crops were favorably affected by the weather during the first two weeks of the month and fairly good progress was noted, though it continued too dry and too warm for the hardier varieties of truck in parts of Florida. The rainfall was especially helpful to fall-planted cane in Louisiana, and the damp weather facilitated the handling of tobacco in the Ohio Valley and Atlantic Coast States. In California the timely rains resulted in marked improvement in truck crops, while peas and lettuce did well in Arizona.

The latter part of the month was rather too cold for best results in the winter trucking districts of the Southeast, and there was considerable damage by frost in the west Gulf area, while some harm from the same cause was reported from California. The warm weather in southern Florida was somewhat unfavorable for citrus fruit, while, on the other hand, considerable damage from frost occurred in parts of California, and some harm was reported from west Gulf districts. In general, however, the citrus outlook continued satisfactory. Damage was reported to peach buds in parts of the central Rocky Mountain area.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, December, 1924

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Alabama	48.6	+1.6	Thomasville	87	7	St. Bernard	11	2	7.05	+2.24	Thomasville	13.54	Millport	3.60
Alaska (November)	24.5	+6.3	Hydaburg	62	15	Allakaket	−32	24	6.56	+0.52	Latouche	24.55	Fort Yukon	0.05
Arizona	41.5	−2.0	Lichton	86	2	Chin Lee	−22	27	1.69	+0.45	Crown King	6.55	Hereford	0.02
Arkansas	41.4	−0.7	Grannis	86	14	Gravette	−8	25	3.65	−0.44	2 stations	5.85	Whitecliffs	1.00
California	44.3	−2.2	4 stations	87	[2] 12	Helm Creek	−28	18	4.18	+0.21	Lake Spaulding	11.77	Mecca	0.07
Colorado	19.3	−5.8	3 stations	73	14	Fraser	−50	25	1.72	+0.54	Savage Basin	8.48	Hartsel	0.12
Florida	63.3	+3.7	5 stations	87	[2] 7	Vernon	23	2	2.26	−0.54	St. Andrew	12.77	Fort Myers	0.01
Georgia	50.1	+3.0	Waycross	85	7	Blue Ridge	8	2	6.39	+2.16	Clayton	10.65	Brunswick	2.10
Hawaii	70.8	+1.1	Waimanalo	90	5	Kula Sanitarium	46	22	5.54	−4.24	Pun Kukui	24.00	Olaa (Kurtistown)	0.42
Idaho	18.8	−6.8	2 stations	62	[2] 11	Felt	−50	19	2.26	+0.16	Prichard	4.61	Challis	0.48
Illinois	25.3	−4.9	4 stations	70	[2] 8	3 stations	−26	28	3.48	+1.34	Tuscola	6.82	Rochelle	1.14
Indiana	27.8	−4.1	Washington	69	7	Rochester	−30	28	4.84	+2.10	Kokomo	8.60	Salem	2.01
Iowa	15.4	−8.7	Keosauqua	62	12	Washta	−33	28	1.79	+0.65	Wescott	2.93	Rockwell City	0.90
Kansas	24.5	−6.9	Liberal	76	12	2 stations	−22	[2] 20	1.53	+0.62	Beaver	3.79	Johnson	0.14
Kentucky	35.9	−1.7	Williamsburg	79	18	Owensboro	−9	28	6.00	+1.92	Brownsville	11.12	Oneonta	3.26
Louisiana	52.3	+0.5	3 stations	88	[2] 7	2 stations	11	[2] 25	5.10	−0.08	Jennings	10.59	Shreveport	2.26
Maryland-Delaware	35.2	+0.6	Cheltenham, Md	76	19	Oakland, Md	−4	29	2.36	−1.00	Milford, Del	3.36	Cumberland, Md	1.07
Michigan	19.8	−4.9	Hartford	60	8	Humboldt	−27	28	2.44	+0.40	Mancelona	5.70	Escanaba	0.90
Minnesota	5.0	−9.9	Winnibigoshish	55	7	Itasca State Park	−39	19	0.87	+0.16	Winona	2.23	Campbell	0.06
Mississippi	48.3	+0.2	Leakesville	87	16	2 stations	7	28	5.68	+0.22	Columbia	10.38	Pontotoc	1.55
Missouri	27.7	−6.2	Hollister	80	16	St. Catharine	−28	28	3.43	+1.40	Mountain Grove	6.70	Bethany	0.67
Montana	13.0	−9.2	2 stations	70	[2] 1	Wheaton	−55	18	1.09	+0.19	Belton	5.26	Sunset Orchard	T.
Nebraska	16.2	−9.6	Scottsbluff	70	15	Weeping Water	−31	28	1.82	+1.08	Beaver City	3.98	Mitchell (near)	0.27
Nevada	26.1	−6.0	Las Vegas	79	[2] 4	San Jacinto	−45	19	1.16	+0.33	Arthur	4.02	Goldfield	0.12
New England	23.2	−2.2	Boston, Mass	64	9	Van Buren, Me	−32	26	1.96	−1.48	Kingston, R. I	3.29	Burlington, Vt	0.61
New Jersey	32.8	−0.2	Burlington	68	9	Charlotteburg	−4	29	2.58	−1.38	Cape May City	3.42	Layton	1.85
New Mexico	30.4	−3.9	Jal	79	2	Dulce	−42	25	0.94	+0.12	Bateman's Ranch	4.87	2 stations	0.00
New York	24.5	−1.9	York	63	8	Indian Lake	−34	28	2.01	−1.03	Copenhagen	4.74	West Berne	0.42
North Carolina	43.4	+2.0	2 stations	82	[2] 7	Parker	−1	21	4.63	+0.73	Rock House	12.03	Louisburg	1.40
North Dakota	2.9	−10.1	Marmarth	58	12	Dunseith	−46	27	0.43	−0.11	Willow City	1.00	Westhope	T.
Ohio	28.5	−2.7	Middleport	74	18	Bellefontaine	−20	28	3.41	+0.62	Upper Sandusky	5.79	Zanesville	1.57
Oklahoma	34.4	−4.7	Poteau	82	1	Hurley	−17	24	1.73	−0.12	Tuskahoma	9.07	Goodwell	0.13
Oregon	28.2	−6.0	Pilot Rock	71	13	2 stations	−53	[2] 24	4.13	−0.27	Government Camp	17.25	Arlington	0.80
Pennsylvania	29.8	−1.1	Uniontown	69	8	West Bingham	−23	28	2.13	−1.10	Corry	4.42	Sunbury	0.56
Porto Rico	74.6	0.0	Mayaguez	93	21	3 stations	55	[2] 15	4.90	+0.17	Rio Grande	22.67	Maricao	0.10
South Carolina	47.6	+1.0	Blackville	86	7	Landrum	12	22	5.54	+2.07	Aiken	9.58	Charleston	2.93
South Dakota	11.6	−9.2	Rapid City	69	12	De Smet	−36	27	0.97	+0.33	Wagner	3.60	Onida	0.11
Tennessee	39.5	−0.6	6 stations	78	[2] 17	Crossville	0	[2] 22	6.61	+2.14	Cedar Hill	9.81	Elizabethton	3.85
Texas	47.1	−2.4	Ricardo	97	[2] 6	Dalhart	−9	19	1.80	−0.36	Angleton	8.36	5 stations	0.00
Utah	20.4	−5.8	Springdale	68	1	Woodruff	−47	[2] 24	2.20	+0.99	Silver Lake	6.77	Salduro	0.22
Virginia	38.8	+1.0	2 stations	80	[2] 8	Rocky Mount	−4	22	3.05	−0.33	Stuart	5.90	Dale Enterprise	1.28
Washington	27.5	−5.5	Sunnyside	69	13	Anatone	−30	18	4.58	−0.40	Quinault	22.76	Rock Island	0.27
West Virginia	33.1	−0.2	Burlington	83	18	Pickens	−8	29	2.58	−0.79	Pickens	5.96	Upper Tract	0.58
Wisconsin	11.6	−8.7	Racine	52	8	Solon Springs	−36	24	1.07	−0.23	Lancaster	1.90	Mather	0.26
Wyoming	14.8	−5.7	Buffalo	71	14	Riverside	−59	19	0.99	+0.27	Afton (near)	2.71	Archer	0.13

[1] For description of tables and charts, see REVIEW, January, 1924, pp. 56–57.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, December, 1924*

Districts and stations	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F	°F.		°F	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*							*0-10*	*In.*	*In.*
New England							**26.9**	**−2.5**										**71**	**1.91**	**−1.5**									**6.4**		
Eastport	76	67	85	29.91	30.00	+.02	21.5	−4.8	52	9	30	−11	21	13	33	20	15	74	2.09	−1.9	12	9,599	w.	37	w.	20	8	7	16	6.6	5.8	0.2
Greenville, Me	1,070	6	----	28.82	30.02	----	14.2	----	44	9	23	−20	21	6	34	→	----	----	1.84	----	12	----	se.	----	----	----	9	6	16	----	11.0	0.0
Portland, Me	103	82	117	29.96	30.09	+.06	24.2	−3.4	56	9	31	−6	21	17	26	21	15	70	2.20	−1.5	10	6,244	sw.	32	w.	20	11	6	14	5.6	3.3	0.4
Concord	288	70	79	29.75	30.08	+.05	22.6	−4.2	56	9	31	−10	21	14	29	----	----	----	1.74	−1.6	7	4,190	nw.	28	nw.	15	10	9	12	5.4	4.1	1.8
Burlington	404	11	48	29.63	30.10	+.05	19.7	−4.7	55	9	28	−13	28	12	29	----	----	----	0.61	−1.1	11	10,476	s.	39	s.	26	4	4	23	7.8	2.8	0.4
Northfield	876	12	60	29.10	30.10	+.05	17.5	−2.9	59	9	27	−20	28	8	34	16	12	80	0.98	−1.7	13	6,085	n.	36	w.	14	4	8	19	7.6	6.5	3.0
Boston	125	115	188	29.96	30.10	+.05	31.1	−1.4	64	9	39	−1	21	23	28	27	20	64	1.48	−1.9	9	8,480	w.	39	w.	15	7	11	13	6.2	0.2	0.0
Nantucket	12	14	90	30.09	30.10	+.05	33.8	−2.0	55	8	40	9	21	28	20	31	26	73	2.61	−1.0	11	12,061	nw.	48	w.	14	5	5	21	7.3	4.5	0.0
Block Island	26	11	46	30.08	30.11	+.05	33.9	−2.1	56	9	39	10	21	28	24	31	25	70	2.54	−1.3	12	15,596	nw.	62	nw.	21	5	8	18	7.1	1.3	0.0
Providence	160	215	251	29.94	30.12	+.06	30.5	−1.1	61	9	38	4	21	23	25	27	20	65	1.96	−1.9	11	7,699	w.	50	nw.	21	10	9	12	5.5	0.6	0.0
Hartford	159	122	140	29.96	30.14	+.07	29.4	−0.4	60	9	37	2	21	22	22	----	----	----	1.90	−1.7	11	----	nw.	----	----	----	12	6	13	5.6	0.5	0.0
New Haven	106	74	153	30.02	30.14	+.07	31.5	−1.0	60	9	38	9	21	25	29	28	23	70	2.85	−0.8	9	6,938	w.	37	w.	14	10	5	16	6.2	1.1	0.0
Middle Atlantic States							**35.3**	**−0.3**										**71**	**2.44**	**−0.7**									**6.6**		
Albany	97	102	115	30.03	30.14	+.06	26.5	−2.0	60	9	34	−4	21	19	26	24	19	77	0.99	−1.6	11	5,709	s.	32	s.	5	5	9	17	7.3	4.4	0.2
Binghamton	871	10	84	29.13	30.09	.00	27.2	−1.0	60	8	35	−4	29	20	31	----	----	----	1.19	−1.2	13	5,300	nw.	30	sw.	9	4	2	25	8.2	2.7	0.5
New York	314	414	454	29.81	30.16	+.07	34.0	−1.0	61	8	41	11	26	27	25	30	23	64	2.38	−1.1	8	14,694	nw.	72	nw.	14	5	9	17	7.1	0.4	0.0
Harrisburg	374	94	104	29.79	30.21	+.09	32.3	−0.4	58	8	39	10	26	26	24	28	22	68	1.63	−1.0	5	5,172	nw.	28	w.	14	7	2	22	7.2	1.0	T.
Philadelphia	114	123	190	30.06	30.20	+.09	36.2	−0.1	66	8	43	13	26	29	25	32	24	63	2.18	−0.9	6	7,258	nw.	33	nw.	14	5	6	20	7.2	0.2	0.0
Reading	325	81	98	29.82	30.19	----	32.9	----	65	8	39	10	26	26	24	30	26	77	1.95	−1.4	7	3,831	nw.	30	w.	14	6	11	14	6.8	0.5	0.0
Scranton	805	111	119	29.27	30.17	+.07	28.8	−1.9	60	8	36	4	26	22	26	26	24	83	1.06	−1.6	12	6,139	sw.	37	sw.	14	3	7	21	7.7	4.6	0.3
Atlantic City	52	37	172	30.12	30.18	+.08	36.9	+0.5	61	17	44	14	26	30	30	33	27	70	3.15	−0.6	9	12,210	nw.	51	ne.	31	13	3	15	5.6	T.	0.0
Cape May	17	13	49	30.20	30.22	+.11	36.8	−1.2	58	17	43	16	29	30	27	34	30	78	3.42	−0.4	8	6,395	nw.	34	s.	5	9	5	17	6.7	T.	T.
Sandy Hook	22	10	55	30.14	30.16	----	33.8	----	58	8	40	13	26	28	24	30	24	67	2.13	----	7	12,927	w.	54	w.	14	4	8	19	7.1	0.3	0.0
Trenton	190	159	183	29.97	30.18	----	34.8	----	64	8	42	11	26	27	26	30	24	66	2.60	−0.6	8	6,082	nw.	45	w.	14	4	9	18	7.1	0.8	0.0
Baltimore	123	100	113	30.06	30.19	+.06	36.8	−0.4	66	19	44	15	26	30	29	32	25	65	2.30	−0.8	9	4,002	sw.	26	w.	14	6	9	16	6.6	T.	T.
Washington	112	62	85	30.08	30.21	+.08	36.4	−0.2	74	19	44	14	26	29	31	32	25	66	2.98	−0.2	8	5,090	nw.	35	nw.	14	6	8	17	6.6	0.5	0.5
Cape Henry	18	8	54	30.17	30.19	----	45.0	----	78	19	52	24	26	38	32	40	36	78	3.06	−0.4	9	11,226	sw.	48	nw.	1	8	9	14	6.2	T.	0.0
Lynchburg	681	153	188	29.44	30.21	+.07	40.2	+0.7	79	18	50	11	22	30	35	34	28	66	3.34	+0.1	6	6,217	w.	36	n.	1	11	9	11	5.0	0.0	0.0
Norfolk	91	170	205	30.12	30.22	+.09	44.4	+1.0	76	8	52	19	21	37	36	39	33	70	2.85	−0.6	8	9,686	ne.	39	ne.	31	8	10	13	5.9	0.0	0.0
Richmond	144	11	52	30.06	30.22	+.08	40.5	+0.7	76	19	49	15	22	32	42	35	30	71	3.40	+0.4	9	6,196	sw.	37	nw.	1	12	4	15	5.9	T.	0.0
Wytheville	2,304	49	55	27.76	30.22	+.07	36.6	+1.3	71	7	46	8	22	27	29	31	26	72	2.94	−0.8	8	5,748	w.	31	w.	19	10	12	9	5.4	0.5	0.5
South Atlantic States							**48.9**	**+1.5**										**77**	**4.11**	**+0.7**									**5.8**		
Asheville	2,255	70	84	27.80	30.24	+.08	40.8	+3.0	78	18	51	13	22	30	36	34	29	70	4.03	+1.0	8	6,639	nw.	33	se.	5	12	8	11	5.1	T.	0.0
Charlotte	779	55	62	29.36	30.22	+.06	44.1	+1.1	75	18	52	19	22	36	31	39	33	69	4.33	+0.5	9	4,209	sw.	26	w.	8	9	9	13	6.1	0.0	0.0
Hatteras	11	11	50	30.18	30.19	+.06	49.8	−0.3	71	8	56	30	2	44	25	47	44	82	4.63	−0.5	12	12,835	n.	42	nw.	31	11	7	13	5.6	0.0	0.0
Manteo	12	5	42	----	----	----	47.2	----	76	18	----	23	2	----	32	----	----	----	7.86	----	11	----	----	----	----	----	12	3	16	----	T.	----
Raleigh	376	103	110	29.81	30.23	+.08	44.0	+1.0	76	18	53	17	22	35	33	39	34	74	3.81	+0.6	10	6,120	sw.	28	w.	8	9	9	13	6.0	0.0	0.0
Wilmington	78	81	91	30.15	30.24	+.09	50.0	+0.9	79	18	59	24	2	41	31	46	43	82	3.32	+0.2	12	5,693	n.	29	sw.	24	12	3	16	6.0	0.0	0.0
Charleston	48	11	92	30.17	30.22	+.07	52.8	+1.1	78	17	60	28	2	45	25	48	46	83	2.93	−0.2	11	7,842	ne.	34	ne.	21	10	7	14	6.1	0.0	0.0
Columbia, S. C	351	41	57	29.84	30.24	+.08	49.0	+1.8	79	18	58	24	2	40	34	43	39	75	6.37	+3.5	7	3,959	ne.	25	sw.	13	11	4	16	5.6	T.	0.0
Due West	711	10	55	29.45	30.24	----	44.8	----	74	17	54	20	2	36	35	----	----	----	5.81	----	9	6,403	ne.	37	w.	8	10	8	13	6.0	0.0	0.0
Greenville, S. C	1,039	113	122	29.09	30.21	----	44.4	+2.2	75	17	52	21	2	36	29	39	34	72	5.84	----	10	4,884	sw.	38	w.	8	12	7	12	5.5	0.0	0.0
Augusta	180	62	77	30.02	30.22	+.06	50.1	+2.0	79	18	59	26	3	42	33	45	41	78	7.11	+3.7	9	3,858	nw.	25	nw.	8	8	9	14	6.0	0.0	0.0
Savannah	65	150	194	30.15	30.22	+.07	54.1	+1.7	80	17	63	30	2	46	30	48	45	80	3.44	+0.3	13	8,732	ne.	32	s.	8	12	5	14	5.9	0.0	0.0
Jacksonville	43	209	245	30.16	30.21	+.07	58.4	+2.1	79	19	06	34	2	50	26	53	51	84	1.15	−1.8	8	9,411	ne.	40	sw.	31	9	6	16	6.2	0.0	0.0
Florida Peninsula							**70.6**	**+4.1**										**82**	**0.43**	**−1.5**									**4.6**		
Key West	22	10	64	30.11	30.13	+.05	73.7	+3.4	82	13	78	58	1	69	16	69	67	86	0.56	−1.3	3	7,307	ne.	25	e.	2	15	13	3	3.6	0.0	0.0
Miami	25	71	79	30.14	30.17	----	72.2	+4.2	81	25	77	49	1	67	25	67	65	81	0.32	−1.7	5	5,881	e.	24	e.	18	9	13	9	5.2	0.0	0.0
Sand Key	23	39	72	30.11	30.14	+.06	73.4	----	82	11	75	65	1	72	10	69	67	81	0.68	----	5	11,878	e.	39	ne.	2	17	9	5	3.6	0.0	0.0
Tampa	35	79	87	30.14	30.18	+.06	65.8	+4.7	82	10	74	43	2	57	25	59	57	81	0.42	−1.6	2	4,482	ne.	24	s.	31	8	12	11	6.0	0.0	0.0
East Gulf States							**50.5**	**+1.0**										**74**	**6.82**	**+2.2**									**6.4**		
Atlanta	1,174	190	216	28.96	30.22	+.06	45.6	+0.9	73	18	54	20	26	38	25	40	35	71	6.39	+1.8	11	8,887	nw.	38	nw.	20	7	8	16	6.5	0.0	0.0
Macon	370	78	87	29.82	30.23	+.07	50.0	+2.5	78	6	59	24	3	41	37	44	39	73	8.18	+3.8	10	4,724	ne.	26	s.	8	8	4	19	6.6	T.	0.0
Thomasville	273	49	58	29.90	30.21	+.06	55.6	+3.1	79	18	65	32	2	46	31	50	46	78	6.64	+3.0	11	3,954	ne.	27	sw.	31	9	7	15	6.4	0.0	0.0
Apalachicola	36	42	49	30.15	30.19	----	56.4	----	71	31	62	36	26	50	28	53	50	85	5.25	----	11	7,249	n.	32	n.	25	7	8	16	6.3	0.0	0.0
Pensacola	56	149	185	30.13	30.19	+.0	54.8	+0.8	73	5	62	30	26	48	26	50	46	78	5.69	+1.5	12	11,581	n.	40	sw.	24	6	5	20	7.1	0.0	0.0
Anniston	741	9	57	29.43	30.24	+.0	46.0	+1.8	75	6	56	17	26	36	36	----	----	----	7.04	+2.5	9	4,815	n.	26	nw.	8	10	9	12	5.6	0.0	0.0
Birmingham	700	11	48	29.45	30.24	+.0	46.8	+0.4	77	6	55	18	26	38	32	41	34	67	6.89	+2.3	11	6,120	n.	32	se.	4	12	7	12	5.6	0.0	0.0
Mobile	57	125	161	30.13	30.19	+.01	53.6	+0.7	77	8	62	28	26	46	29	49	44	77	7.35	+2.8	12	9,169	n.	38	n.	20	5	10	16	6.6	0.0	0.0
Montgomery	223	100	112	29.97	30.22	+.0	50.6	+1.2	80	6	59	25	26	42	31	45	38	68	7.31	+2.8	12	5,734	se.	26	e.	31	8	9	14	6.5	T.	0.0
Corinth	469	6	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Meridian	375	85	93	29.81	30.22	+.06	48.3	+0.6	79	16	57	19	26	40	37	43	37	70	8.38	+3.2	10	5,136	n.	25	ws.	8	11	4	16	6.0	0.0	0.0
Vicksburg	247	65	73	29.94	30.23	+.08	49.0	−1.0	82	16	58	19	26	40	40	43	38	71	4.40	−0.6	10	5,847	ne.	25	s.	7	8	6	17	6.5	0.0	0.0
New Orleans	53	76	84	30.12	30.18	+.05	55.7	+0.1	81	16	63	31	21	48	34	51	48	79	6.72	+2.3	12	6,148	ne.	24	ne.	20	5	8	18	7.4	0.0	0.0
West Gulf States							**48.3**	**−2.1**										**74**	**2.56**	**−0.3**									**6.5**		
Shreveport	249	77	93	29.93	30.21	+0.8	47.8	−1.3	81	16	56	18	25	39	34	42	35	65	2.26	−2.1	9	5,810	se.	27	s.	7	13	8	10	5.3	T.	0.0
Bentonville	1,303	11	44	----	----	----	34.2	−3.3	68	12	44	1	19	24	33	----	----	----	3.68	----	9	4,076	s.	34	sw.	5	16	6	9	----	1.1	0.0
Fort Smith	457	79	94	29.70	30.20	+.07	38.4	−3.7	77	16	47	9	20	29	40	33	28	71	4.44	+1.6	9	7,063	e.	34	w.	7	11	7	13	5.5	T.	0.0
Little Rock	357	136	144	29.81	30.20	+.06	41.8	−2.4	78	17	51	9	28	32	34	37	29	63	1.88	−2.4	11	7,204	s.	42	s.	7	13	5	13	5.2	T.	0.0
Brownsville	57	53	61	30.05	30.11	----	57.9	−3.3	83	6	65	26	21	50	43	53	51	86	3.53	----	13	7,724	n.	27	sw.	7	1	11	19	7.5	T.	0.0
Corpus Christi	20	11	73	30.14	30.16	+.04	55.8	−2.2	88	7	62	23	20	50	46	51	48	82	2.67	+1.4	11	10,416	n.	44	n.	19	5	9	17	7.4	0.3	0.0
Dallas	512	109	117	29.64	30.21	----	45.6	----	79	15	55	10	19	36	50	----	----	----	1.54	----	6	6,054	nw.	32	nw.	18	11	4	16	6.1	0.2	0.0
Fort Worth	670	106	114	29.44	30.17	+.05	44.9	−2.6	80	15	54	7	19	35	36	39	35	74	1.23	0.0	2	7,190	nw.	36	w.	4	10	5	16	5.9	T.	0.0
Galveston	54	106	114	30.12	30.18	+.06	54.6	−1.8	73	16	60	28	20	49	37	50	47	82	5.33	+1.6	11	9,481	n.	34	se.	3	5	11	15	6.9	0.2	0.0
Groesbeck	461	11	56	29.69	30.18	----	47.4	----	82	7	57	12	19	38	51	----	----	----	1.39	----	8	8,949	n.	37	w.	4	10	7	14	6.1	T.	0.0
Houston	138	111	121	30.03	30.18	----	53.9	−0.5	80	18	62	22	20	46	45	----	----	----	3.77	----	12	6,254	n.	33	se.	2	4	10	17	7.2	T.	0.0
Palestine	510	64	72	29.65	30.19	+.07	48.1	−1.8	82	7	57	16	20	39	49	42	36	66	1.77	−1.9	8	6,526	n.	30	s.	7	9	8	14	6.1	0.0	0.0
Port Arthur	34	58	66	30.13	30.17	----	52.8	----	76	14	60	27	21	46	36	48	45	81	4.11	----	16	8,167	n.	29	n.	19	5	6	20	7.5	0.0	0.0
San Antonio	693	119	132	29.42	30.16	+.05	52.6	−1.1	82	7	62	21	20	44	34	47	42	71	2.31	+0.8	9	6,044	n.	31	nw.	4	5	8	18	7.3	0.0	0.0
Taylor	583	55	63	29.58	30.20	+.09	49.3	−1.3	81	7	59	16	20	40	50	----	----	----	1.11	−1.5	7	7,228	nw.	31	n.	19	5	9	17	6.7	0.1	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, December, 1924*—Continued

Districts and stations	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Ohio Valley and Tennessee							**34.1**	**−2.3**										**74**	**4.43**	**+1.0**										**6.6**		
Chattahooga	762	189	213	29.41	30.24	+.08	42.0	−1.3	75	17	50	16	26	34	32	37	30	65	7.71	+3.4	12	5,792	ne.	31	sw.	5	10	9	12	5.8	T.	0.0
Knoxville	996	102	111	29.15	30.24	+.08	40.2	−0.1	74	17	48	14	21	32	32	36	31	73	8.46	+4.3	10	4,920	ne.	36	sw.	5	7	12	12	5.9	T.	0.0
Memphis	399	76	97	29.79	30.23	+.08	41.8	−1.8	76	17	50	6	28	33	52	36	30	66	5.32	+0.9	10	5,908	n.	50	w.	7	14	4	13	5.0	T.	0.0
Nashville	546	168	191	29.65	30.26	+.11	39.6	−1.4	75	17	49	6	28	30	50	35	30	74	5.36	+1.5	11	7,740	s.	44	se.	8	10	6	15	5.9	T.	0.0
Lexington	989	193	230	29.13	30.24	+.10	34.0	−1.8	68	17	42	3	25	26	48	----	----	----	5.59	+2.3	10	10,691	sw.	48	sw.	8	10	8	13	5.9	1.8	0.0
Louisville	525	188	234	29.64	30.25	+.11	33.8	−3.8	66	17	43	−3	28	25	48	30	24	68	4.10	+0.4	11	8,657	s.	36	w.	8	9	7	15	6.2	3.7	T.
Evansville	431	139	175	29.75	30.24	+.11	33.3	−3.8	68	18	42	−10	28	25	33	50	25	72	3.80	0.0	10	8,513	sw.	31	sw.	5	10	8	13	6.2	3.3	T.
Indianapolis	822	194	230	29.29	30.21	+.09	28.2	−4.0	64	17	36	−13	28	20	42	25	22	79	5.53	+2.5	12	9,341	nw.	42	nw.	13	6	7	18	6.9	2.3	1.7
Royal Center	736	11	55	29.36	30.20	------	22.5	------	57	7	31	−25	28	14	34	----	----	----	5.78	------	15	8,520	sw.	40	nw.	13	4	7	20	7.7	6.1	4.0
Terre Haute	575	96	129	29.57	30.22	------	28.2	------	64	16	36	−16	28	20	31	26	22	80	6.67	------	12	7,712	s.	32	w.	8	6	10	15	6.5	5.7	1.7
Cincinnati	628	11	51	29.52	30.22	+.09	31.0	−2.4	65	17	40	−3	28	22	48	----	26	81	3.16	+0.2	9	6,664	sw.	38	sw.	8	8	6	17	6.6	1.8	T.
Columbus	824	179	222	29.30	30.21	+.09	29.0	−3.4	64	16	37	−3	25	21	40	26	22	76	2.35	−0.4	10	8,863	w.	56	nw.	13	5	5	21	7.6	2.0	0.7
Dayton	899	137	173	29.21	30.20	------	29.0	−3.6	63	16	37	−6	28	21	48	26	22	76	3.57	+1.0	13	8,288	sw.	46	nw.	13	7	7	17	6.9	2.0	0.2
Elkins	1,947	59	67	28.08	30.23	+.11	31.8	−0.9	68	18	42	0	26	22	43	28	25	81	2.69	−0.7	18	5,024	w.	31	sw.	13	4	11	16	7.1	2.3	0.0
Parkersburg	638	77	84	29.56	30.24	+.10	33.6	−1.6	72	18	42	4	28	25	37	29	24	70	2.49	−0.3	13	5,026	sw.	31	w.	13	4	8	19	7.5	0.6	0.0
Pittsburgh	842	353	410	29.26	30.20	+.09	31.4	−2.8	64	17	39	0	28	24	31	28	24	73	1.95	−0.8	13	9,492	sw.	50	w.	13	3	2	26	8.6	3.4	1.0
Lower Lake Region							**24.8**	**−4.3**										**78**	**2.83**	**−0.1**										**8.0**		
Buffalo	767	247	280	29.26	30.13	+.07	25.2	−4.6	58	8	31	2	28	19	24	23	20	81	3.49	+0.1	19	17,937	w.	80	w.	9	2	4	25	8.6	26.3	11.5
Canton	448	10	61	29.56	30.07	------	17.4	−5.3	58	8	26	−22	28	9	44	----	----	----	1.82	−1.8	13	9,253	sw.	53	w.	9	4	6	21	7.9	9.2	6.0
Oswego	335	76	91	------	30.12	+.06	24.3	−4.7	59	8	32	−4	21	17	27	----	----	82	1.71	−1.9	16	------	s.	43	nw.	14	2	2	27	----	22.4	6.8
Rochester	523	86	102	29.54	30.13	+.07	25.9	−3.4	62	8	32	1	28	20	28	23	18	74	2.28	−0.6	19	7,860	w.	38	w.	9	2	4	25	8.5	14.7	2.0
Syracuse	597	97	113	29.45	30.12	+.05	26.0	−2.3	60	8	33	−6	21	19	30	----	----	----	1.66	−1.0	16	9,996	w.	45	w.	14	2	5	24	8.4	11.3	1.0
Erie	714	130	166	29.34	30.14	+.07	27.7	−4.2	63	8	34	0	26	22	30	26	22	78	2.79	−0.3	19	13,734	sw.	53	se.	5	1	2	28	9.3	12.3	6.0
Cleveland	762	190	201	29.32	30.17	+.08	27.6	−3.6	60	8	34	−5	25	21	33	25	21	75	3.58	+1.0	18	10,741	sw.	58	w.	14	2	3	26	8.6	5.6	1.5
Sandusky	629	62	70	29.46	30.17	+.08	26.6	−4.6	59	8	33	−8	25	20	37	----	----	----	3.98	+1.6	13	7,232	sw.	40	nw.	13	4	3	24	7.9	4.3	1.6
Toledo	628	208	243	29.47	30.18	+.10	24.8	−5.6	58	8	32	−9	25	18	27	23	18	75	3.42	+1.1	14	12,313	sw.	54	w.	13	8	5	18	6.7	4.8	2.9
Fort Wayne	856	113	124	29.23	30.19	------	24.0	−3.3	57	8	32	−17	28	16	29	22	18	79	5.29	------	11	8,003	sw.	42	w.	13	5	9	17	7.0	3.7	1.5
Detroit	730	218	258	29.34	30.16	+.09	23.2	−6.1	56	8	29	−8	25	17	24	22	19	82	3.54	+1.2	18	9,704	sw.	43	nw.	13	3	9	19	7.6	7.4	2.8
Upper Lake Region							**17.5**	**−7.2**										**82**	**1.72**	**−0.4**										**7.5**		
Alpena	609	13	92	29.39	30.09	+.07	19.8	−5.0	45	8	26	−7	28	13	29	19	16	83	1.40	−0.8	12	9,612	sw.	43	nw.	13	4	8	19	7.4	5.9	3.1
Escanaba	612	54	60	29.42	30.12	+.09	13.6	−8.8	36	7	21	−19	28	6	27	12	10	85	0.90	−0.8	10	7,863	nw.	35	nw.	13	8	6	17	6.2	10.1	2.0
Grand Haven	632	54	89	29.42	30.14	+.09	24.2	−5.1	55	8	30	3	27	18	29	23	20	83	1.26	−1.2	21	11,779	w.	60	w.	13	2	3	26	8.9	9.0	2.8
Grand Rapids	707	70	87	29.35	30.15	+.10	23.2	−5.3	55	8	29	−2	28	17	29	21	18	80	1.66	−0.9	17	5,351	nw.	39	se.	7	0	4	27	9.2	12.5	4.5
Houghton	668	62	99	29.33	30.09	+.07	12.9	−8.9	36	12	18	−13	29	7	34	----	----	----	4.31	+1.8	22	8,848	w.	48	nw.	13	1	2	28	9.4	43.6	18.0
Lansing	878	11	62	29.15	30.14	------	21.0	−6.2	55	8	28	−9	28	14	30	20	17	83	1.97	−0.1	16	5,729	sw.	28	nw.	13	5	8	18	6.9	5.3	2.5
Ludington	637	60	66	29.39	30.12	------	23.0	------	50	8	28	1	27	18	24	21	18	81	1.62	------	23	11,101	w.	47	nw.	13	0	3	28	9.0	16.0	3.0
Marquette	734	77	111	29.27	30.12	+.10	14.6	−8.0	36	7	21	−17	28	8	32	12	9	82	1.53	−1.0	14	9,223	w.	32	w.	13	5	6	20	7.6	14.4	9.7
Port Huron	638	70	120	29.41	30.13	+.07	22.0	−5.6	55	8	28	−9	28	16	24	21	18	84	1.77	−0.4	19	9,682	sw.	45	nw.	13	3	10	18	7.6	9.2	4.2
Saginaw	641	69	77	29.41	30.14	------	21.0	−6.2	56	8	28	−8	28	14	29	20	17	83	1.82	−0.1	14	7,179	sw.	34	sw.	9	2	11	18	7.9	4.5	2.9
Sault Ste. Marie	614	11	52	29.34	30.07	+.07	13.8	−6.7	36	2	21	−11	29	7	30	12	9	82	2.75	+0.4	19	7,150	sw.	47	nw.	13	1	6	24	8.8	22.9	12.5
Chicago	823	140	310	29.25	30.18	+.10	23.4	−6.6	56	8	30	−13	28	16	33	21	16	72	1.90	−0.2	12	9,511	w.	34	w.	8	8	11	12	5.9	3.3	0.8
Green Bay	617	109	144	29.43	30.14	+.10	14.0	−8.3	37	8	21	−20	28	7	30	12	10	87	0.80	−1.0	10	9,209	sw.	52	w.	13	12	6	13	5.6	4.1	1.7
Milwaukee	681	125	139	29.38	30.16	+.10	18.4	−7.7	47	8	26	−16	28	11	35	17	13	78	1.25	−0.7	12	9,251	w.	42	e.	4	10	5	16	6.2	5.1	1.2
Duluth	1,133	5	47	28.86	30.17	+.12	3.6	−12.3	34	12	12	−28	27	−5	47	2	1	91	0.79	−0.4	9	11,676	sw.	54	w.	13	11	6	14	5.5	8.4	6.9
North Dakota							**2.9**	**−9.1**										**83**	**0.48**	**−0.1**										**6.1**		
Moorhead	940	50	58	29.16	30.25	+.17	2.0	−9.5	37	12	11	−30	28	−7	51	1	−2	81	0.37	−0.4	8	6,394	n.	28	nw.	12	10	7	14	5.7	3.0	0.8
Bismarck	1,674	8	57	28.39	30.30	+.22	5.5	−9.2	56	12	16	−29	27	−5	49	4	1	83	0.23	−0.4	7	7,233	nw.	36	n.	24	9	7	15	6.4	3.3	1.8
Devils Lake	1,478	11	44	28.54	30.24	+.18	−0.7	−8.7	38	1	9	−31	27	−10	51	−1	−4	87	0.67	+0.3	10	7,794	w.	35	n.	26	7	9	15	6.2	9.4	4.0
Ellendale	1,457	10	56	28.58	30.24	------	4.6	------	52	12	15	−28	28	−5	44	----	----	----	0.65	------	9	11,174	nw.	47	nw.	24	8	7	16	6.5	8.5	4.3
Grand Forks	835	12	89	------	------	------	1.0	------	40	1	12	−29	27	−1	52	−1	----	----	0.56	------	8	------	nw.	52	s.	1	12	2	17	----	3.6	3.0
Williston	1,878	41	48	28.14	30.26	+.20	4.7	−9.1	48	1	13	−31	27	−4	48	3	0	80	0.66	0.0	7	6,508	w.	31	w.	22	13	3	15	5.6	7.2	3.5
Upper Mississippi Valley							**19.4**	**−7.4**										**80**	**2.38**	**+0.6**										**6.0**		
Minneapolis	918	102	208	29.14	30.18	------	9.2	−10.4	45	2	17	−20	27	1	39	----	----	----	0.83	−0.1	8	9,100	nw.	40	nw.	26	6	13	12	5.9	10.0	6.2
St. Paul	837	236	261	29.25	30.21	+.13	8.8	−10.2	44	2	17	−23	28	1	39	----	----	----	1.36	+0.3	8	9,630	nw.	50	nw.	13	7	12	12	5.8	11.7	4.0
La Crosse	714	11	48	29.39	30.21	+.13	12.6	−9.7	44	2	20	−22	28	5	30	----	----	----	1.57	+0.2	12	4,384	w.	26	w.	13	11	5	15	5.7	10.1	2.5
Madison	974	70	78	29.08	30.20	+.12	15.0	−7.8	39	2	22	−21	28	8	31	13	10	81	1.16	−0.6	12	7,508	sw.	32	nw.	13	11	3	17	6.5	5.3	2.5
Wausau	1,247	4	----	28.75	30.16	------	10.0	------	36	2	17	−23	28	3	31	----	----	----	0.91	------	10	------	nw.	----	----	----	12	4	15	5.6	8.5	3.3
Charles City	1,015	10	49	29.07	30.21	+.11	11.6	−8.8	46	2	20	−21	28	4	32	10	8	86	2.06	+0.8	12	5,619	w.	24	ne.	4	11	3	17	5.8	10.4	5.6
Davenport	606	71	79	29.52	30.22	+.12	19.6	−7.5	48	12	27	−20	28	12	32	17	12	81	2.36	+0.7	13	6,212	w.	29	e.	4	12	4	15	5.7	5.6	2.0
Des Moines	861	84	97	29.26	30.22	+.11	17.7	−8.4	55	12	26	−21	28	10	30	16	13	85	1.62	+0.3	11	6,254	w.	25	sw.	2	10	5	16	6.3	4.8	1.0
Dubuque	700	81	96	29.39	30.19	+.09	16.4	−8.3	41	12	24	−19	28	9	33	14	11	80	1.31	−0.4	12	5,398	nw.	27	nw.	13	10	4	17	6.4	3.5	2.3
Keokuk	614	64	78	29.52	30.23	+.11	23.0	−6.6	60	12	32	−19	28	14	35	20	14	73	2.19	+0.3	10	6,593	w.	36	sw.	8	6	10	15	6.5	7.8	2.9
Cairo	358	87	93	29.83	30.22	+.07	35.2	−2.6	70	16	44	−3	28	26	31	31	26	70	3.76	+0.4	9	7,594	s.	33	n.	27	10	3	18	6.3	2.5	0.0
Peoria	609	11	45	29.52	30.22	+.11	21.8	−6.3	52	8	30	−24	28	13	34	20	18	89	2.40	0.0	13	5,987	s.	31	w.	8	10	9	12	5.9	6.6	3.7
Springfield, Ill	636	10	91	29.49	30.20	+.08	25.6	−6.1	56	7	33	−14	28	18	32	23	21	87	4.72	+2.3	8	6,531	s.	27	se.	4	11	7	13	5.7	1.5	0.3
Hannibal	534	74	109	29.64	30.24	+.12	25.0	−6.5	59	12	33	−16	28	16	32	----	----	----	3.36	+1.7	7	7,054	sw.	35	w.	8	11	6	14	5.5	3.4	4.0
St. Louis	568	265	303	29.58	30.21	+.08	30.0	−4.8	69	16	38	−8	28	22	32	26	21	72	4.63	+2.4	7	9,733	s.	40	s.	4	10	5	16	6.0	2.1	0.8
Missouri Valley							**19.5**	**−8.1**										**79**	**2.21**	**+1.2**										**6.0**		
Columbia, Mo	784	11	84	29.35	30.23	+.11	26.6	−6.6	62	15	35	−12	28	18	29	----	*	----	4.76	+2.8	9	6,644	se.	35	sw.	8	10	10	11	5.4	1.4	5.1
Kansas City	963	161	181	29.14	30.22	+.10	25.8	−6.7	63	15	34	−10	28	18	31	22	18	75	2.76	+1.4	9	8,496	n.	35	w.	8	11	8	12	5.3	7.1	4.1
St. Joseph	967	11	49	29.13	30.21	------	22.6	------	58	15	31	−13	28	14	29	19	17	85	2.73	------	9	6,915	nw.	38	nw.	8	11	9	11	5.5	5.6	3.2
Springfield, Mo	1,324	98	104	28.74	30.20	+.07	30.4	−5.8	72	16	40	−5	28	21	34	27	23	81	4.21	+1.5	7	8,379	se.	35	sw.	5	15	5	11	5.0	1.0	0.0
Iola	984	11	50	29.12	30.22	+.10	28.0	−4.5	70	12	38	−5	28	18	35	----	----	----	1.70	+0.8	9	5,604	n.	26	ne.	27	11	6	14	5.9	2.6	1.0
Topeka	987	92	107	------	------	------	24.4	−7.6	66	12	33	−9	28	16	31	----	----	----	2.16	+1.3	10	7,612	n.	31	nw.	8	10	9	12	5.8	5.6	2.5
Drexel	1,299	10	54	28.76	30.22	------	14.8	------	50	2	23	−19	27	7	26	----	----	----	1.74	------	9	8,841	n.	32	s.	10	10	5	16	6.2	11.3	3.0
Lincoln	1,189	11	84	28.90	30.24	+.12	18.5	−9.1	53	2	26	−15	27	11	34	16	13	82	1.98	+1.3	7	7,779	n.	33	nw.	8	7	5	19	6.7	8.5	1.2
Omaha	1,105	115	122	28.99	30.24	+.13	17.4	−9.0	51	2	25	−14	27	10	27	15	12	80	1.38	+0.5	12	6,990	nw.	33	n.	26	7	10	14	6.0	6.0	1.8
Valentine	2,598	47	54	27.37	30.25	+.15	13.7	−10.9	54	12	23	−21	19	4	38	12	10	84	1.56	+0.9	12	6,855	w.	34	s.	1	5	11	15	6.4	20.8	9.2
Sioux City	1,135	94	164	28.97	30.26	+.14	13.4	−9.7	52	12	21	−20	28	6	35	11	7	77	1.87	+1.1	9	9,513	nw.	42	nw.	8	9	9	13	5.9	18.5	3.4
Huron	1,306	59	74	28.80	30.29	+.19	10.3	−8.4	57	12	19	−21	27	2	39	8	4	76	0.69	+0.1	7	7,687	nw.	32	nw.	8	7	11	13	6.1	9.0	1.8
Pierre	1,572	70	75	28.52	30.29	+.19	12.6	−9.2	55	12	21	−17	27	4	41	11	6	74	0.95	+0.4	7	6,426	nw.	37	nw.	24	9	3	19	6.5	13.8	4.0
Yankton	1,233	49	57	28.85	30.25	+.14	12.4	−10.2	52	12	21	−20	28	4	39	----	----	----	2.53	+1.8	9	6,829	w.	28	nw.	23	7	6	18	6.9	29.9	5.2

TABLE 1.—*Climatological data for Weather Bureau stations, December, 1924*—Continued

Districts and stations	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month.
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Northern Slope							**13.5**	**−10.3**										**76**	**1.31**	**+0.5**										**6.6**		
Billings	3,140	5		17.3			8.8	−11.6	66	14	29	−33	18	5	63				0.82		10		nw.				12	2	17		0.0	0.0
Havre	2,505	11	44	27.48	30.28	+.23	13.4	−10.8	58	12	18	−36	18	0	45	8	6	87	1.19	+0.6	12	6,331	sw.	36	w.	12	3	5	23	7.8	11.2	10.3
Helena	4,110	87	112	25.86	30.28	+.15	14.7	−10.2	63	14	23	−30	18	4	47	11	7	77	0.61	−0.2	14	4,549	sw.	55	sw.	12	7	6	18	7.0	8.4	5.2
Kalispell	2,973	48	56	27.04	30.28	+.21	11.0	−10.0	57	13	22	−27	18	8	65	12	9	81	2.49	+0.6	13	4,255	nw.	42	n.	15	6	3	22	7.4	25.0	17.0
Miles City	2,371	48	55	27.63	30.34	+.24	15.5	−11.4	64	12	21	−43	19	1	44	9	5	76	1.05	+0.4	13	4,685	ne.	30	w.	12	9	3	19	6.7	10.0	8.6
Rapid City	3,259	50	58	26.67	30.29	+.20	21.3	−7.2	69	12	27	−25	18	4	62	12	7	70	0.95	+0.5	9	5,007	n.	44	nw.	24	8	8	15	6.2	12.9	5.0
Cheyenne	6,088	84	101	23.93	30.13	+0.4	21.3	−7.2	60	15	31	−16	19	12	34	17	10	67	0.78	+0.5	11	2,088	w.	59	w.	25	10	6	15	6.2	8.3	1.5
Lander	5,372	60	68	24.64	30.28	+.13	11.1	−9.3	61	14	23	−40	19	−1	47	8	2	70	1.47	+0.8	9	2,859	sw.	32	nw.	14	9	11	11	5.5	16.9	6.2
Sheridan	3,790	10	47	26.15	30.25		15.8		66	12	28	−33	18	4	54	12	5	68	1.12		15	3,691	nw.	38	nw.	24	10	8	13	6.0	8.6	3.3
Yellowstone Park	6,241	11	48	23.87	30.30	+.14	10.6	−11.0	40	15	19	−34	18	2	49	9	6	81	1.46	−0.4	15	6,040	s.	39	s.	15	7	5	19	7.0	17.4	15.0
North Platte	2,821	11	51	27.18	30.28	+.18	15.2	−11.5	60	2	26	−22	19	5	37	12	9	84	1.81	+1.3	9	5,458	w.	28	n.	3	11	4	16	6.0	16.8	4.1
Middle Slope							**25.7**	**−7.8**										**74**	**1.41**	**+0.6**										**5.5**		
Denver	5,292	106	113	24.70	30.14	+.06	25.6	−6.7	69	14	36	−15	24	15	45	20	12	64	1.42	+0.8	12	4,057	s.	24	nw.	24	10	9	12	5.4	18.4	4.0
Pueblo	4,685	80	86	25.28	30.15	+.07	23.5	−8.0	73	14	38	−19	19	9	52	18	11	64	0.97	+0.5	8	4,444	nw.	28	w.	7	9	14	8	5.2	9.7	4.4
Concordia	1,392	50	58	28.68	30.23	+.11	21.7	−9.0	60	12	30	−9	24	13	30	18	15	81	1.33	+0.8	8	6,325	nw.	28	nw.	8	8	8	15	6.2	7.0	2.7
Dodge City	2,509	11	51	27.51	30.24	+.14	24.0	−8.6	67	14	36	−10	19	12	41	20	18	88	1.13	+0.6	9	7,324	nw.	37	nw.	4	12	7	12	5.5	7.1	3.2
Wichita	1,358	139	158	28.69	30.19	+0.8	27.0	−7.6	64	15	36	−6	28	18	38	23	18	74	1.21	+0.4	7	9,591	s.	36	nw.	8	10	10	11	5.5	5.6	0.9
Broken Arrow	765	11	52	29.36	30.21		32.6		73	16	42	−2	28	23	38				1.97		5	9,859	n.	37	n.	18	13	7	11	5.1	T.	0.5
Muskogee	652	4					35.2		78	16	45	1	19	25	38				3.99		7		se.				12	9	10		0.4	0.0
Oklahoma City	1,214	10	47	28.88	30.21	+.10	32.6	−6.7	73	12	42	−2	19	23	40	28	24	74	2.41	+0.7	5	7,519	n.	30	w.	4	11	6	14	5.5	T.	2.0
Southern Slope							**40.4**	**−3.7**										**65**	**0.66**	**−0.2**										**5.0**		
Abilene	1,738	10	52	28.32	30.18	+.07	42.6	−3.4	79	15	54	5	19	31	39	35	28	64	1.45	+0.3	6	7,427	s.	37	nw.	4	11	7	13	5.3	2.0	0.0
Amarillo	3,676	10	49		30.16	+.07	31.9	−5.1	71	15	45	−6	19	19	53			75	0.63	−0.2	8	8,041	sw.	42	nw.	4	9	10	12		5.7	0.3
Del Rio	944	64	71	29.14	30.15	+.05	51.1	−1.1	81	6	60	23	20	42	33				0.25	−0.6	2	6,256	se.	32	n.	19	9	4	18	6.5	0.0	0.0
Roswell	3,566	75	85	26.41	30.12	+.05	36.0	−5.2	72	16	51	1	25	21	48	28	19	56	0.31	−0.2	2	5,630	s.	39	sw.	16	17	11	3	3.3	3.4	0.0
Southern Plateau							**39.6**	**−2.2**										**57**	**0.90**	**+0.3**										**3.9**		
El Paso	3,762	110	133	26.25	30.09	+.06	42.6	−2.3	68	2	53	19	25	33	37	35	24	52	0.05	−0.5	3	8,039	nw.	50	w.	23	9	15	7	4.7	T.	0.0
Santa Fe	7,013	38	53	23.20	30.14	+.08	25.4	−5.3	52	2	36	−5	25	15	30	21	16	71	1.52	+0.8	10	4,683	ne.	28	w.	6	16	6	9	4.4	20.0	1.4
Flagstaff	6,907	10	59	23.31	30.07	+.01	25.0	−3.4	60	1	38	−16	26	12	55	20		64	3.68		9		w.	48	e.	9	19	7	5		26.5	8.0
Phoenix	1,108	10	82	28.90	30.08	+.04	52.0	0.0	80	1	64	29	28	40	37	42	32	55	1.16	+0.6	6	3,627	e.	28	s.	16	18	5	8	3.7	0.0	0.0
Yuma	141	9	54	29.94	30.09	+.04	53.0	−2.2	79	1	64	33	18	42	35	42	29	44	0.50	0.0	3	5,377	n.	35	n.	24	22	5	4	2.7	0.0	0.0
Independence	3,957	5	25	26.06	30.17	+.05	39.5	+0.2	70	12	51	10	25	28	33	30			1.26	+0.5	5						17	7	7			6.5	0.0
Middle Plateau							**22.7**	**−7.6**										**74**	**1.67**	**+0.8**										**5.5**		
Reno	4,532	74	81	25.55	30.22	+.07	30.8	−2.9	59	1	41	0	25	20	37	27	23	74	0.47	−0.7	11	3,894	w.	37	w.	2	9	13	9	5.3	3.9	0.0
Tonopah	6,090	12	20				27.0		50	15	33	−4	24	21	27	24	19	70	0.34		5		nw.								3.0	0.0
Winnemucca	4,344	18	56	25.74	30.32	+.14	17.2	−12.8	50	1	30	−27	24	5	37	16	13	81	1.85	+0.9	12	4,785	ne.	26	w.	4	6	12	13	6.3	13.9	4.0
Modena	5,479	10	43	24.66	30.22	+.10	20.2	−7.9	58	1	34	−22	25	7	43	17	12	74	1.14	+0.6	8	6,773	w.	58	sw.	16	15	10	6	3.9	10.5	1.2
Salt Lake City	4,360	163	203	25.71	30.23	+.08	24.2	−7.7	50	16	31	−8	26	17	25	22	18	75	3.35	+2.0	14	3,764	nw.	33	s.	16	8	4	19	6.3	34.1	9.4
Grand Junction	4,602	60	68	25.48	30.20	+.10	21.0	−6.5	52	16	32	−21	26	11	35	18	13	72	1.54	+1.1	12	3,357	nw.	42	s.	17	9	10	12	5.5	15.2	7.0
Northern Plateau							**22.9**	**−8.5**										**82**	**1.70**	**0.0**										**7.3**		
Baker	3,471	48	53	26.57	30.31	+.15	18.0	−9.3	49	15	27	−22	18	9	29	16	13	81	1.16	−0.4	12	4,522	se.	22	s.	15	5	8	18	7.2	15.1	5.5
Boise	2,739	78	86	27.35	30.35	+.15	21.8	−10.3	54	15	29	−18	26	14	39	20	16	77	3.02	+1.3	10	3,133	nw.	28	se.	4	6	7	18	6.8	19.4	6.5
Lewiston	757	40	48	29.42	30.27	+.14	27.4	−8.3	61	11	34	−10	24	21	30				0.85	−0.7	12	2,619	e.	18	s.	12	5	2	24	8.1	2.7	0.0
Pocatello	4,477	60	68	25.55	30.27	+.08	19.8	−7.9	52	15	28	−18	19	11	33	19	15	79	1.35	+0.5	13	7,291	se.	46	s.	16	6	4	21	7.4	15.1	3.0
Spokane	1,929	101	110	28.12	30.26	+.18	24.0	−6.5	55	11	30	−8	18	18	39	23	21	88	1.97	−0.6	10	4,219	sw.	32	se.	15	7	4	20	7.0	10.7	8.0
Walla Walla	991	57	65	29.16	30.28	+.16	26.6	−8.9	66	13	33	−4	25	20	28	24	22	84	1.88	−0.2	14	3,181	s.	22	sw.	12	8	3	20	7.2	7.9	2.7
North Pacific Coast Region							**37.6**	**−4.7**										**83**	**6.91**	**−0.6**										**7.2**		
North Head	211	11	56	29.91	30.15	+.12	39.2	−4.9	53	3	43	16	17	35	20	37	33	81	10.37	+2.9	21	12,882	e.	56	s.	1	6	3	22	7.5	1.3	0.0
Port Angeles	29	8	53		30.16		37.5		64	10	44	10	18	31	24				2.74	−2.4	15	4,905	s.	36	n.	15	7	9	15		2.5	0.0
Seattle	125	215	250	30.06	30.19	+.18	37.2	−4.5	56	11	42	12	18	33	27	35	32	81	4.63	−0.7	14	7,605	s.	68	sw.	11	9	2	20	7.0	7.3	0.0
Tacoma	194	172	201	29.96	30.17	+.16	36.6	−4.0	58	11	42	7	18	31	27				6.01	−0.9	18	6,480	s.	44	n.	15	6	3	22	7.6	4.5	0.0
Tatoosh Island	86	9	53	30.00	30.10	+.14	40.2	−3.7	52	11	43	20	16	38	18	39	36	85	14.96	+0.4	20	18,142	e.	81	e.	20	7	6	18	6.9	0.2	0.0
Yakima	1,071	5					23.9		66	12	34	−10	22	14	34				0.42		7		ne.				6	11	14	6.4	1.3	1.0
Medford	1,425	4					34.6		52	30	40	9	18	29	30	32	30	84	3.44		14		se.	28	se.	1	2	3	26			
Portland, Oreg.	153	68	106	30.04	30.21	+.14	36.6	−4.6	60	11	41	11	18	32	20	34	29	76	4.44	−2.5	15	5,198	e.	30	sw.	2	9	1	21	7.1	3.7	0.0
Roseburg	510	9	57	29.63	30.20	+.09	35.5	−6.3	57	10	40	11	25	30	17	34	33	90	5.25	−0.7	14	1,691	nw.	19	sw.	4	1	12	18	7.9	1.6	0.0
Middle Pacific Coast Region							**44.8**	**−3.9**										**82**	**4.22**	**−0.3**										**6.1**		
Eureka	62	73	89	30.10	30.17	+.05	45.5	−2.7	62	29	52	24	18	39	23	43	40	80	4.07	−3.2	18	4,226	se.	32	n.	17	8	4	19	6.7	0.0	0.0
Point Reyes	490	7	18	29.56	30.08		47.9	−2.7	64	13	52	34	18	44	17				6.24		13	12,394	s.	60	nw.	6	11	6	14	5.6	0.0	0.0
Red Bluff	332	50	56	29.83	30.20	+.06	40.2	−5.9	76	13	47	17	26	34	35	38	35	82	4.10	−0.4	12	3,577	nw.	30	nw.	23	8	7	16	6.1	11.8	0.0
Sacramento	69	106	117	30.12	30.19	+.05	42.2	−4.0	59	1	47	25	19	38	18	41	39	86	3.63	+0.1	13	4,753	n.	24	se.	8	7	7	17	6.6	0.0	0.0
San Francisco	155	208	243	29.98	30.16	+.04	47.8	−3.5	62	8	52	36	18	43	13	44	40	78	7.37	−3.1	14	5,366	nw.	38	ne.	5	12	5	14	5.5	0.0	0.0
San Jose	141	12	110	30.01	30.17		45.4	−4.5	68	13	54	22	26	37	32				1.92	−1.1	12	3,836	s.	35	se.	5	9	8	14	5.9	0.0	0.0
South Pacific Coast Region							**51.8**	**−1.2**										**68**	**1.52**	**−0.6**										**4.9**		
Fresno	327	89	98	29.82	30.19	+.06	45.4	−0.8	62	8	52	25	25	39	24	42	40	82	1.61	+0.1	9	3,475	nw.	29	nw.	2	5	10	16	6.8	0.0	0.0
Los Angeles	338	159	191	29.73	30.10	+.03	55.4	−1.2	80	12	66	36	25	47	28	46	36	56	1.10	−1.8	5	3,842	ne.	30	s.	16	16	8	7	4.1	0.0	0.0
San Diego	87	62	70	30.00	30.09	+.02	54.0	−2.0	74	12	62	36	25	46	26	48	42	70	1.34	−0.5	9	4,458	nw.	42	s.	16	14	7	16	4.6	0.0	0.0
San Luis Obispo	201	32	40	29.93	30.15	+.04	52.2	−0.8	80	13	63	30	26	42	35	44	37	64	2.04	−0.3	8	2,647	n.	19	w.	5	18	5	8	4.1	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.95	30.04		**76.4**	**+0.1**	83	1	81	67	30	72	13				8.38	+2.3	27	11,768	e.	43	e.	19	7	21	3	5.0	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	29.73	29.86	+.01	79.0	−0.9	89	22	86	69	29	72	18	74	73	91	8.31	+4.1	15	4,138	nw.	20	n.	14	0	20	11	7.0	0.0	0.0
Colon	36	7	97	29.83	29.87	+.02	80.2	+0.3	88	17	85	72	29	75	14	76	75	88	8.84	−2.2	23	8,381	n.	30	nw.	3	3	19	9	6.0	0.0	0.0
Alaska																																
Juneau	80	11	54				27.6		49	3	32	−2	14	23	22	25	18	69	4.31		14	6,737	e.	40	e.	27	13	3	15	5.6	24.4	0.6

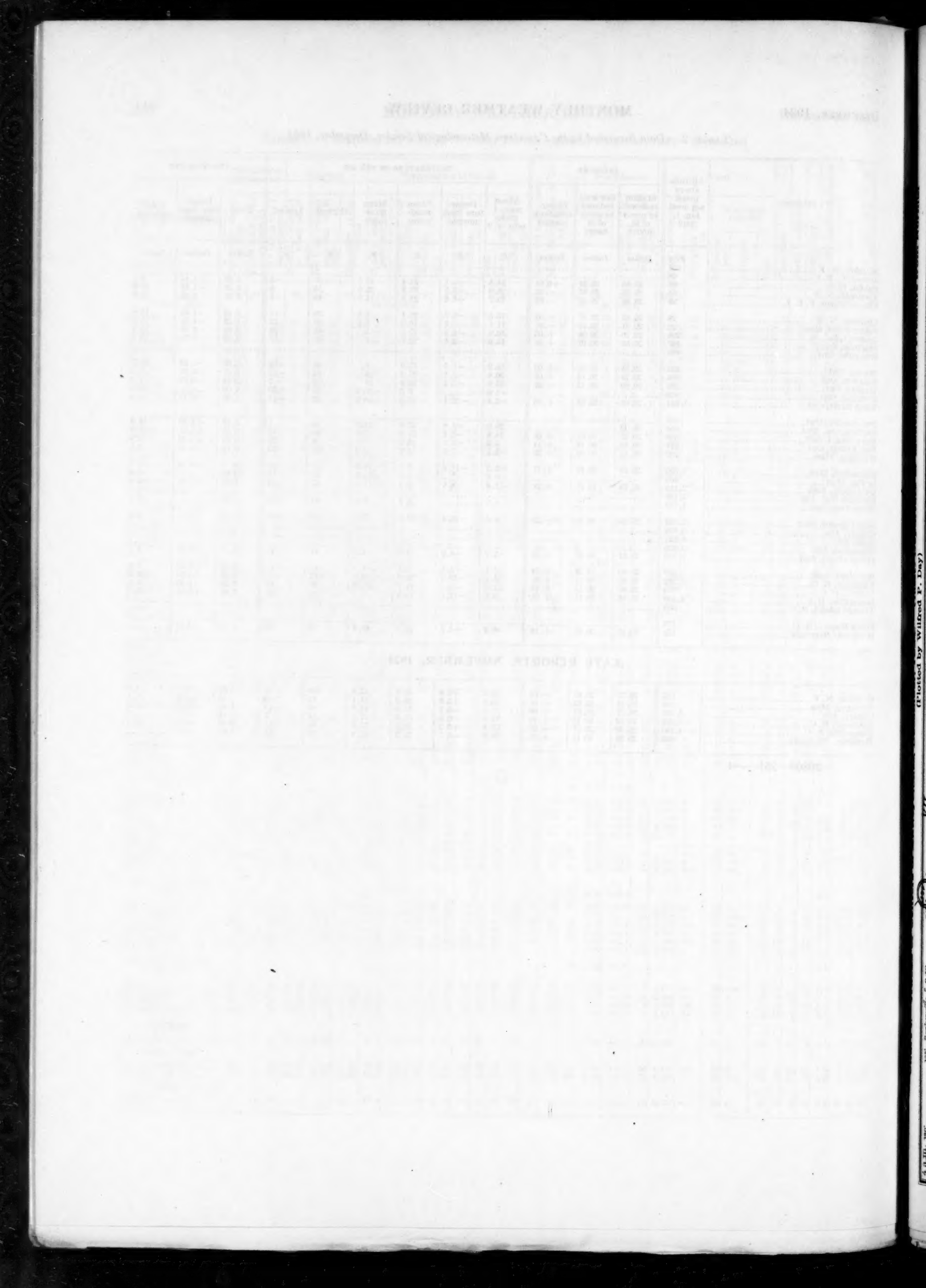
TABLE 2.—*Data furnished by the Canadian Meteorological Service, December, 1924*

STATIONS	Altitude above mean sea level Jan. 1, 1919	PRESSURE			TEMPERATURE OF THE AIR						PRECIPITATION		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*Inches*	*Inches*	*Inches*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*
St. Johns, N. F.	125												
Sydney, C. B. I.	48												
Halifax, N. S.	88	29.86	29.97	+0.01	24.5	−3.1	31.4	17.7	53	−3	3.97	−1.15	8.3
Yarmouth, N. S.	65	29.88	29.95	−.03	28.0	−2.7	33.8	22.3	50	0	3.23	−1.81	10.6
Charlottetown, P. E. I.	38	29.88	29.92	−.02	19.7	−4.6	25.5	14.0	46	−5	1.57	−2.09	10.0
Chatham, N. B.	28	29.83	29.87	−.07	13.3	−3.7	22.1	4.5	38	−16	2.18	−1.04	13.6
Father Point, Que.	20	29.91	29.94	−.01	11.1	−4.3	16.2	6.1	36	13	1.52	−1.31	15.2
Quebec, Que.	296	29.70	30.04	+.03	10.9	−4.3	17.1	5	40	−20	2.94	−0.75	20.1
Montreal, Que.	187	29.85	30.07	+.04	15.9	−2.4	22.7	9	47	−17	3.30	−0.35	16.4
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.81	30.10	+.08	15.0	−2.0	21.9	8	46	−18	1.69	−1.22	10.3
Kingston, Ont.	285	29.78	30.12	+.08	20.6	−3.1	27.2	14	52	−10	2.37	−0.87	9.6
Toronto, Ont.	379	29.69	30.12	+.07	23.9	−3.1	30.2	18	53	−2	2.34	−0.57	11.5
Cochrane, Ont.	930				−1.0		8.2	−10.2	28	−30	1.00		10.0
White River, Ont.	1,244	28.63	30.03	+.06	−0.4	−10.1	10.0	−18.0	30	−45	1.58	−0.13	15.8
Port Stanley, Ont.	592												
Southampton, Ont.	656	29.32			20.9	−5.8	27.0	14.9	53	1	5.37	+1.39	44.9
Parry Sound, Ont.	688	29.33	30.07	+.06	14.8	−6.4	21.8	7.8	48	−15	6.52	+2.04	52.9
Port Arthur, Ont.	644	29.36	30.13	+.14	3.9	−9.3	10.8	−2.9	34	−25	0.89	+0.02	8.9
Winnipeg, Man.	760	29.32	30.22	+.20	−3.1	−7.2	3.8	−10.0	36	−29	0.72	−0.19	7.1
Minnedosa, Man.	1,690	28.24	30.19	+.17	−5.5	−11.2	3.6	−14.5	37	−34	0.46	−0.16	4.6
Le Pas, Man.	860				−9.4		−0.6	−18.2	38	−40	0.40		4.0
Qu'Appelle, Sask.	2,115	27.79	30.21	+.21	−1.4	−8.8	8.4	−11.2	43	−34	1.38	+0.86	13.8
Medicine Hat, Alb.	2,144												
Moose Jaw, Sask.	1,759				1.9		8.7	−4.9	44	−30	1.00		10.0
Swift Current, Sask.	2,392	27.56	30.27	+.28	4.6	−11.4	13.0	−3.7	48	−32	0.93	+0.15	9.3
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Edmonton, Alb.	2,150												
Prince Albert, Sask.	1,450	28.57	30.27	+.26	−3.2	−6.0	8.0	−14.3	44	−43	0.51	−0.23	4.5
Battleford, Sask.	1,592	28.40	30.28	+.29	−1.4	−6.8	8.4	−11.2	45	−41	0.52	+0.20	5.2
Kamloops, B. C.	1,262	28.96	30.34	+.40	15.3	−13.6	20.8	9.9	55	−21	4.18	+3.40	39.2
Victoria, B. C.	230	29.89	30.15	+.18	37.6	−3.6	41.7	33.6	58	12	6.29	−1.69	0.5
Barkerville, B. C.	4,180	25.64	30.14	+.26	9.8	−11.1	15.5	4.1	43	−32	3.57	+0.40	28.9
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Bermuda	151	30.10	30.26	+.14	66.2	+1.5	71.9	60.6	76	50	1.57	−2.92	

LATE REPORTS, NOVEMBER, 1924

St. Johns, N. F.	125	29.73	29.87	−.07	38.3	+1.8	43.8	32.8	60	24	4.86	−0.71	1.0
Winnepeg, Man.	760	29.13	30.02	+.07	20.0	+2.0	26.0	14.1	41	−5	1.16	+0.08	11.4
Calgary, Alb.	3,428	26.37	30.07	+.09	25.6	−0.2	37.0	14.3	64	−16	1.40	+0.52	14.0
Kamloops, B. C.	1,262	28.82	30.15	+.19	32.5	−0.9	37.9	27.1	54	7	0.71	−0.75	1.7
Barkerville, B. C.	4,180	25.58	29.97	+.07	23.8	+0.2	30.1	17.5	44	−11	2.89	−0.40	25.5
Hamilton, Bermuda	656	29.94	30.10	+.05	68.0	−0.7	73.2	62.8	79	55	4.01	−0.37	

30808—25†——4



(Plotted by Wilfred P. Day)

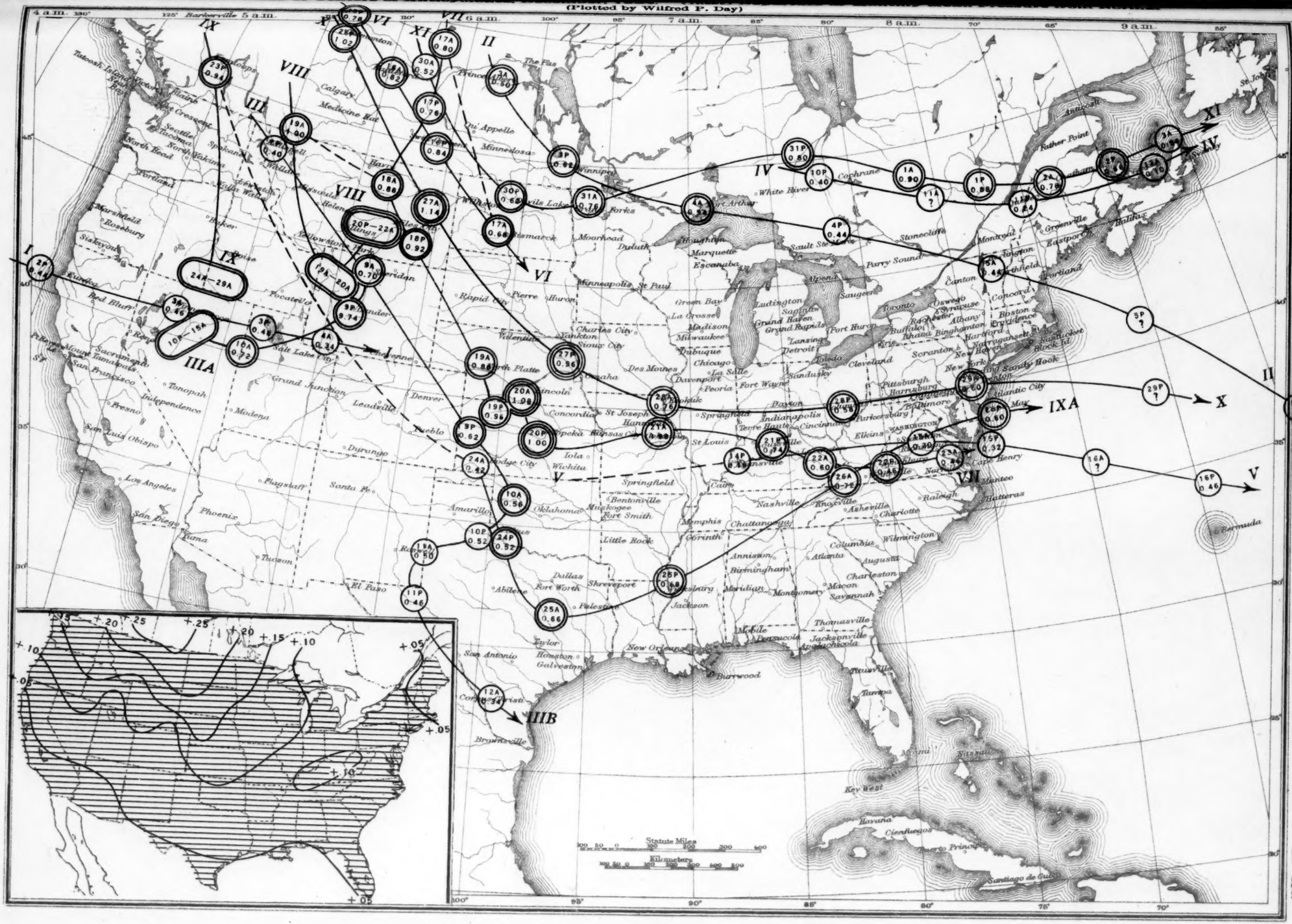
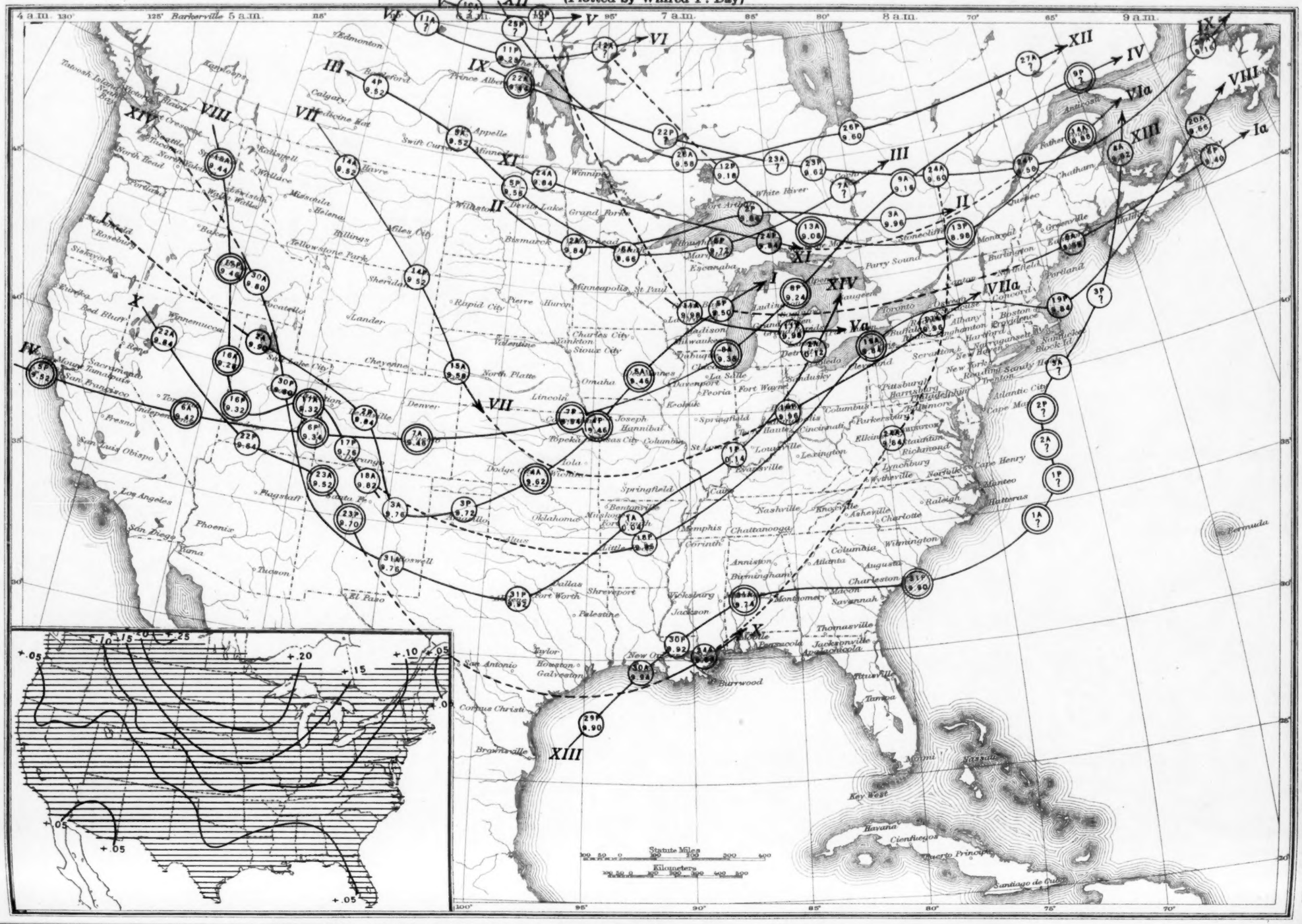


Chart II. Tracks of Centers of Cyclones, December, 1924. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by Wilfred P. Day)


4 a.m.
5 a.m.
6 a.m.
7 a.m.
8 a.m.
9 a.m.
Barkerville
Edmonton
Calgary
Medicine Hat
Kamloops
Swift Current
Prince Albert
Winnipeg
White River
Fort Arthur
Devils Lake
Grand Forks
Bismarck
Minneapolis
St Paul
Rapid City
Pierre
Huron
Sheridan
Billings
Miles City
Helena
Missoula
Havre
Yellowstone Park
Lander
Valentine
Charles City
Kinkton
Sioux City
Omaha
North Platte
Lincoln
Denver
Chevenne
Salt Lake City
Winnemucca
Red Bluff
Roseburg
Eureka
Portland
Seattle
Tacoma
Spokane
Walla Walla
Lewiston
Baker
Boise
Modena
Sacramento
San Francisco
Fresno
San Luis Obispo
Los Angeles
San Diego
Phoenix
Yuma
Tucson
Flagstaff
El Paso
Albuquerque
Roswell
Amarillo
Dodge City
Wichita
Topeka
Kansas City
Joseph
Hannibal
Springfield
Columbia
St Louis
Peoria
Davenport
Rockford
Madison
Milwaukee
Dubuque
Chicago
La Salle
Fort Wayne
Sandusky
Detroit
Toledo
Cleveland
Buffalo
Toronto
Kingston
Ogdensburg
Montreal
Quebec
Father Point
Anticosti
Chatham
Moncton
Parry Sound
Escanaba
Marquette
Houghton
Duluth
Winnipeg
Prince Albert
Swift Current
Medicine Hat
Calgary
Edmonton
Kamloops
Tatoosh Island
Neah Bay
Port Angeles
Seattle
Tacoma
Olympia
Walla Walla
Lewiston
Spokane
Havre
Miles City
Billings
Helena
Missoula
Butte
Bismarck
Devils Lake
Grand Forks
Minneapolis
St Paul
Rapid City
Pierre
Huron
Sheridan

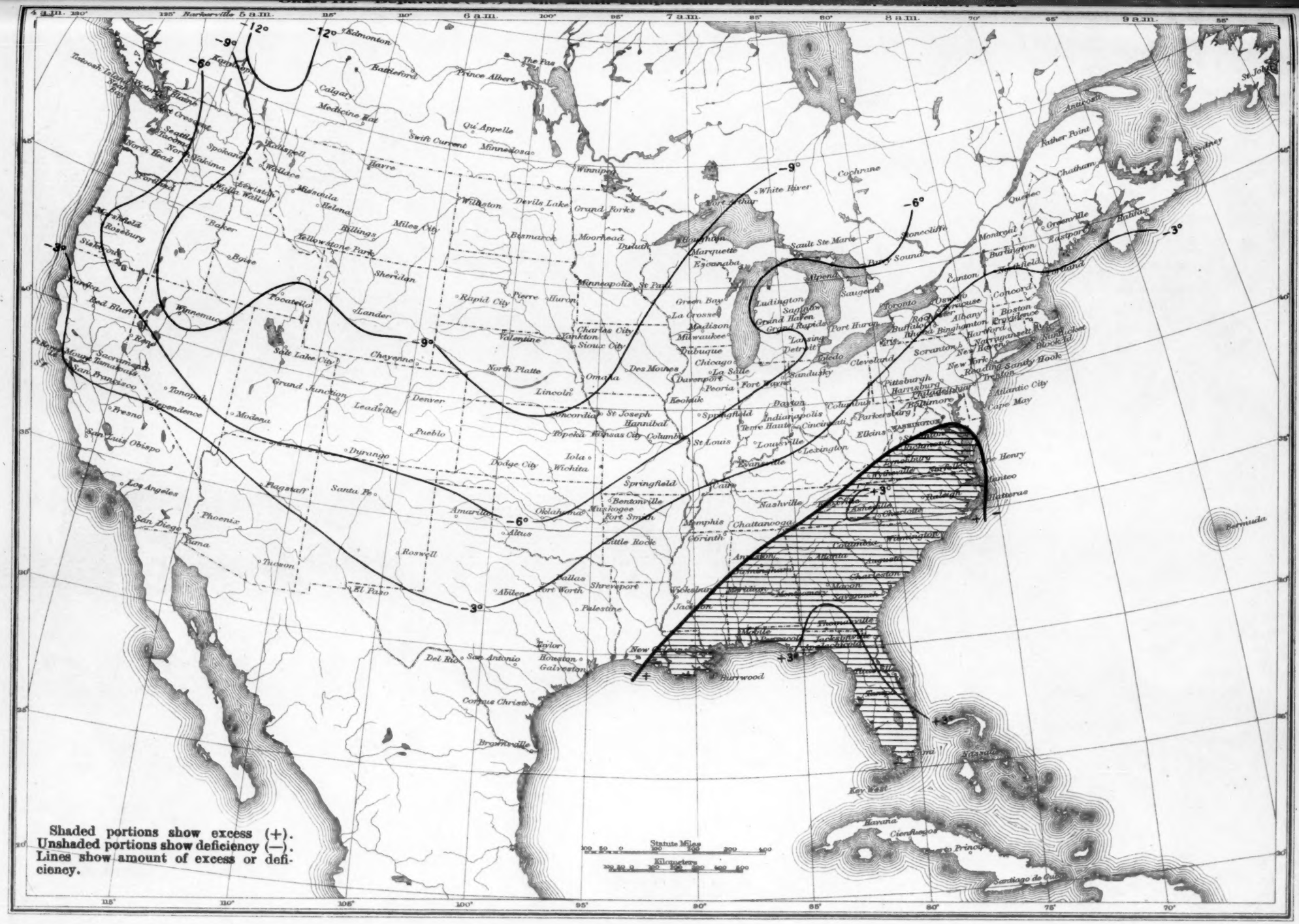
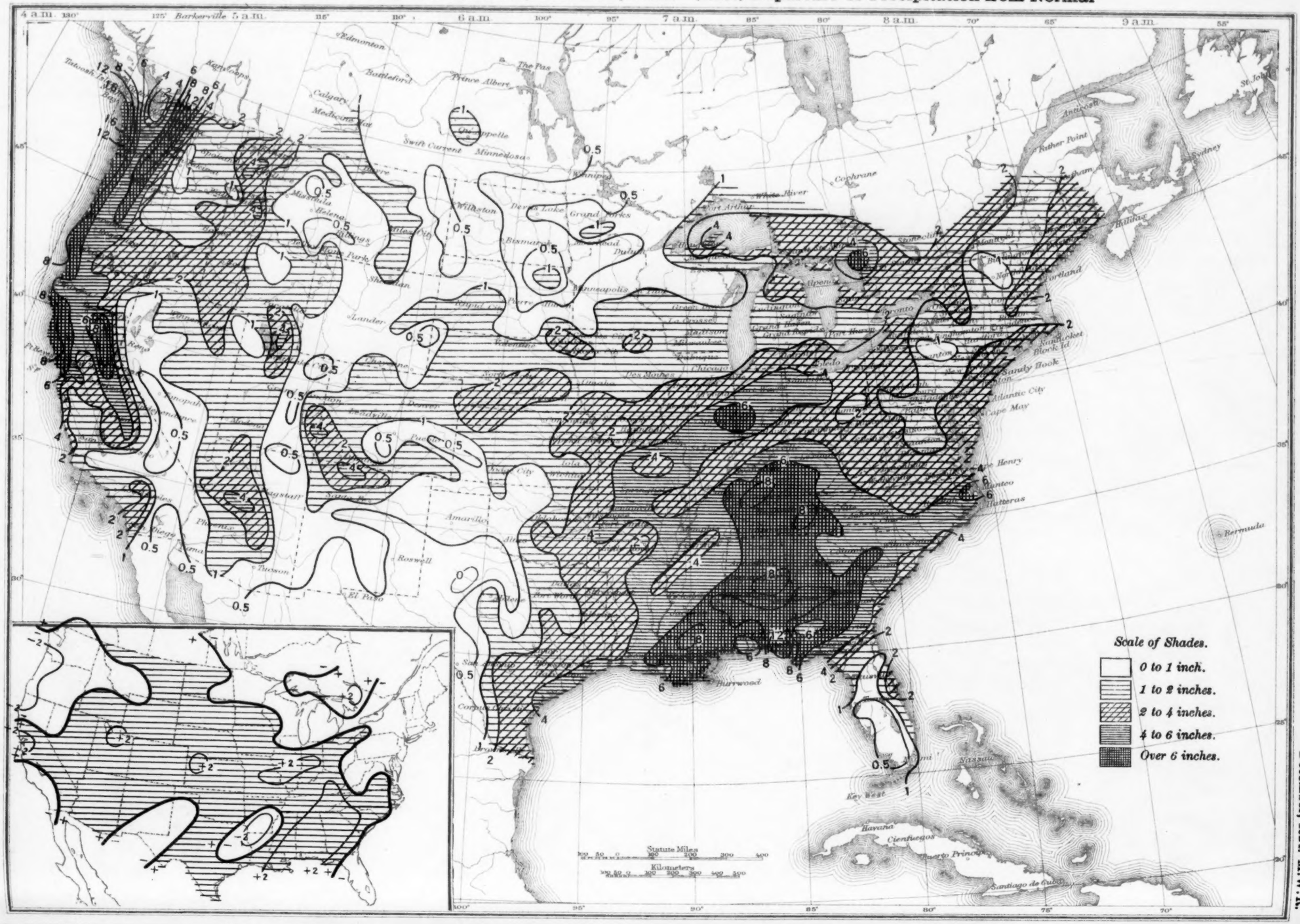

Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.
Statute Miles
Kilometers
-12°
-9°
-6°
-3°
+3°

Chart IV. Total Precipitation, Inches, December, 1924. (Inset) Departure of Precipitation from Normal



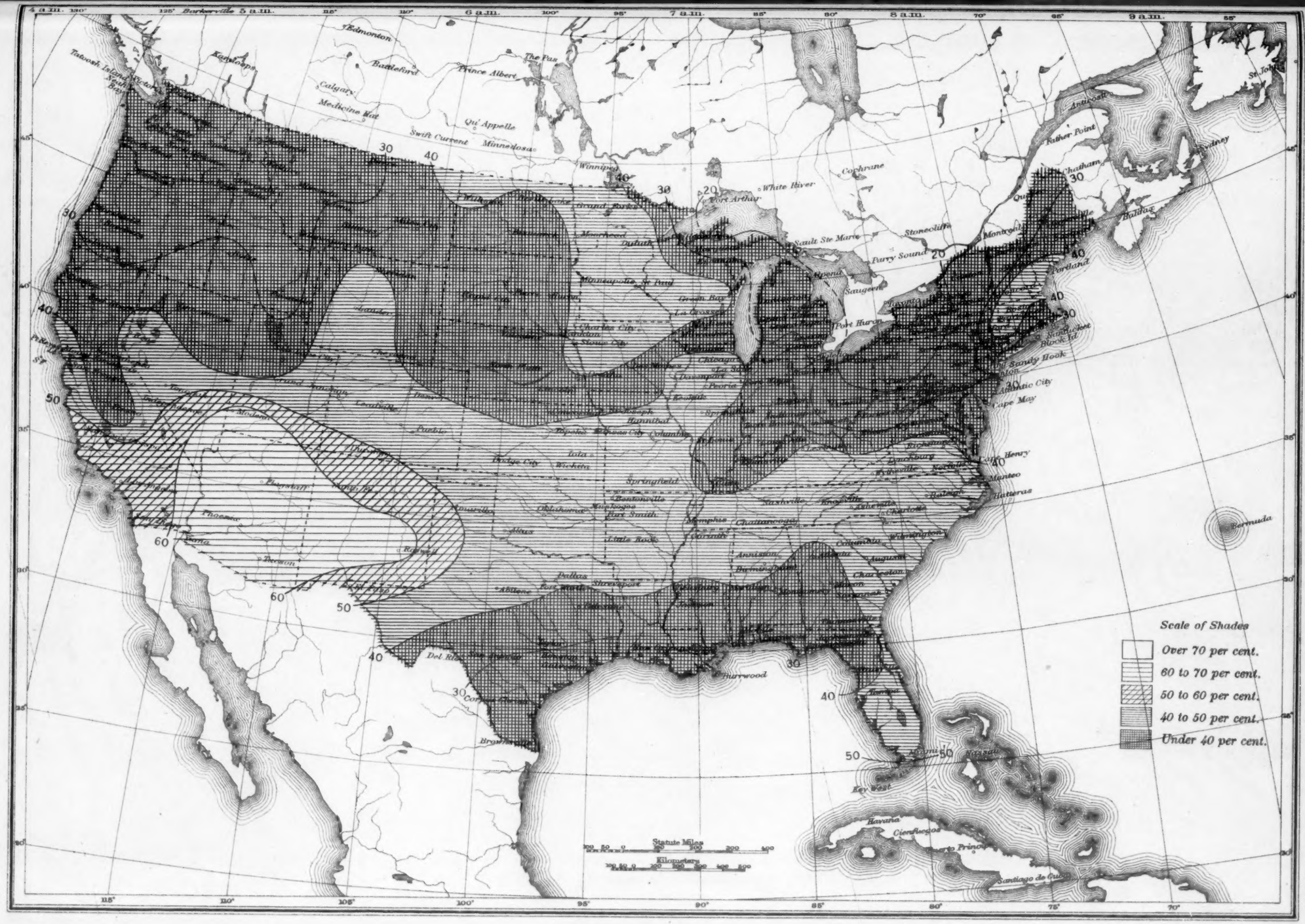
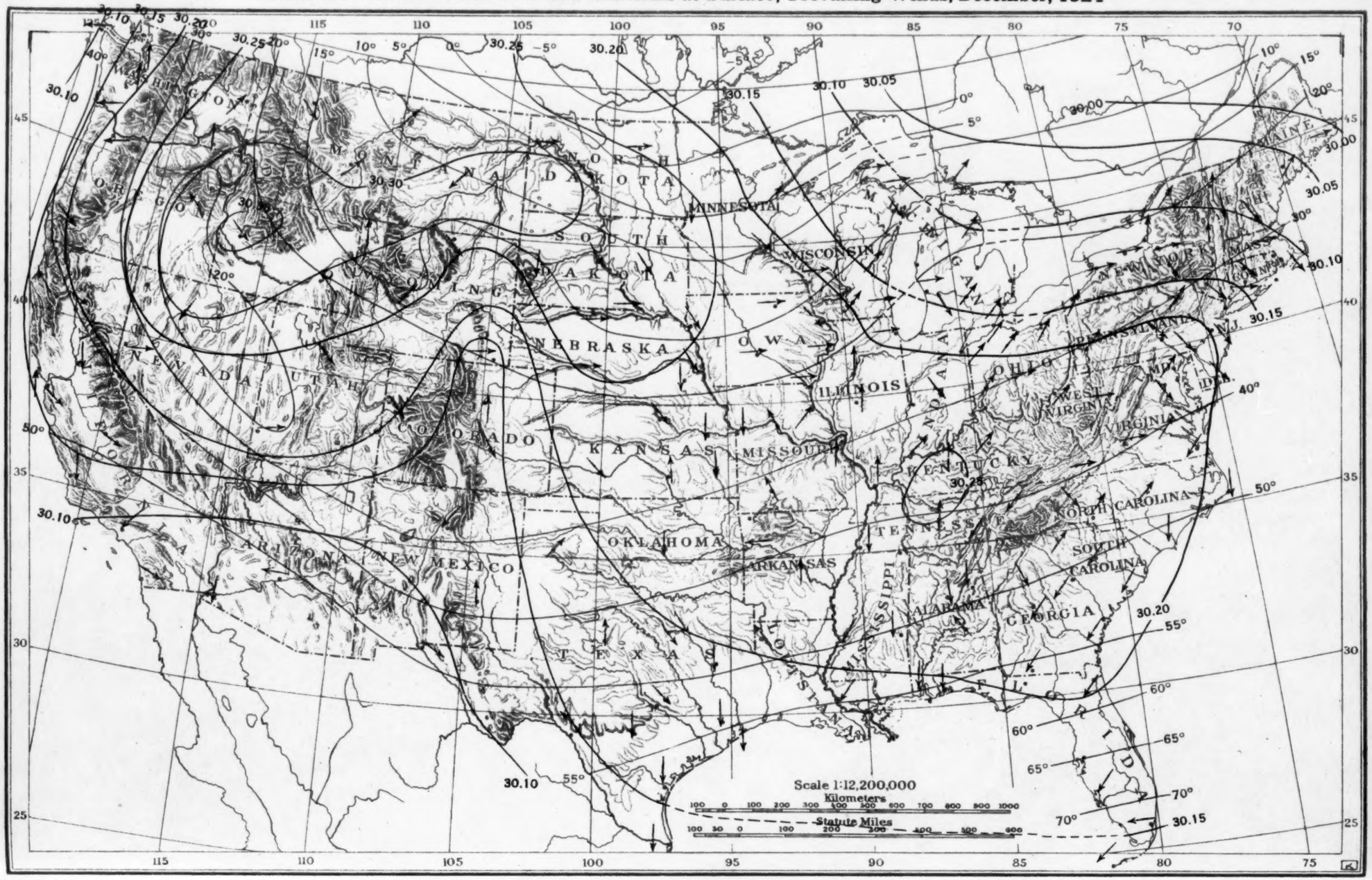
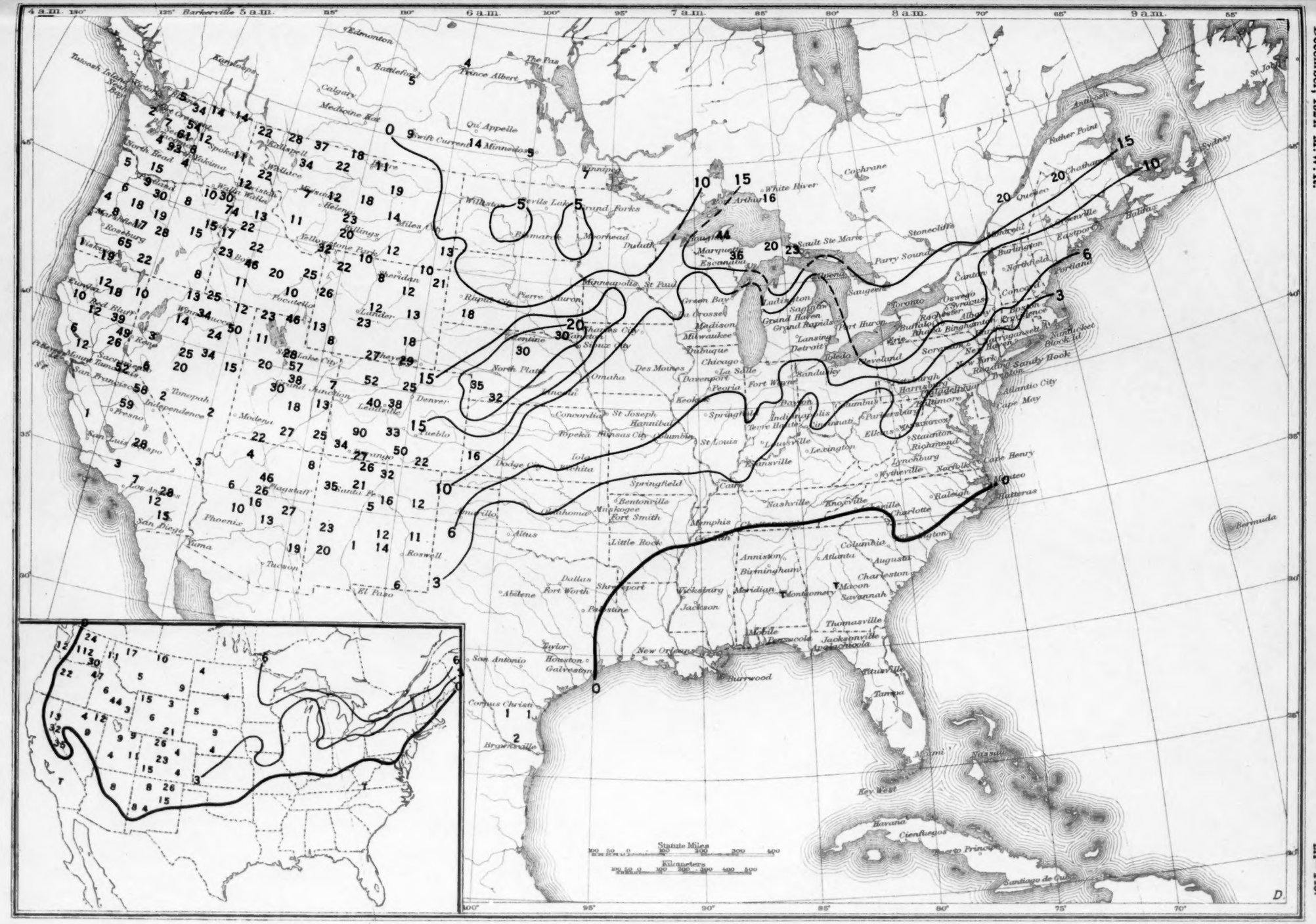

Scale of Shades
Over 70 per cent.
60 to 70 per cent.
50 to 60 per cent.
40 to 50 per cent.
Under 40 per cent.
Statute Miles
Kilometers
Barkerville
Edmonton
Battleford
Prince Albert
The Pas
Calgary
Medicine Hat
Qu'Appelle
Swift Current
Minnedosa
Winnipeg
White River
Cochrane
Port Arthur
Sault Ste Marie
Stonecliffe
Parry Sound
Father Point
Chatham
Portland
Saugeen
Point Hurop
Sandy Hook
Atlantic City
Cape May
Cape Henry
Manteo
Hatteras
Bermuda
Key West
Havana
Cienfuegos
Santiago de Cuba
Tatoosh Island
Fort Canby
Pt Reyes
Fresno
Yuma
Phoenix
Tucson
Abilene
Fort Worth
Shreveport
Pensacola
Tallahassee
Jacksonville
Charleston
Wilmington
Norfolk
Richmond
Washington
Baltimore
Philadelphia
Atlantic City
Harrisburg
Pittsburgh
Buffalo
Toronto
Kingston
Montreal
Quebec
Portland
Boston
Albany
Rochester
Detroit
Cleveland
Toledo
Chicago
Milwaukee
Green Bay
Minneapolis
St Paul
Duluth
Moorhead
Grand Forks
Devils Lake
Williston
Miles City
Billings
Havre
Great Falls
Helena
Butte
Spokane
Seattle
Tacoma
Portland
Roseburg
Eureka
Red Bluff
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
Salt Lake City
Ogden
Pocatello
Boise
Winnemucca
Reno
Carson City
Virginia City
Tonopah
Las Vegas
Grand Junction
Denver
Pueblo
Colorado Springs
Cheyenne
North Platte
Omaha
Lincoln
Des Moines
Davenport
Rock Island
Peoria
Springfield
Hannibal
St Louis
Kansas City
Topeka
Wichita
Dodge City
Concordia
Salina
Hutchinson
Amarillo
Childress
Abilene
Fort Worth
Dallas
Waco
Austin
San Antonio
Del Rio
Eagle Pass
Laredo
Brownsville
Corpus Christi
Galveston
Houston
Beaumont
Port Arthur
Lake Charles
New Orleans
Baton Rouge
Vicksburg
Jackson
Meridian
Mobile
Montgomery
Birmingham
Tuscaloosa
Selma
Columbus
Atlanta
Macon
Augusta
Columbia
Charleston
Savannah
Jacksonville
Tallahassee
Pensacola
Mobile
New Orleans
Memphis
Nashville
Chattanooga
Knoxville
Asheville
Greensboro
Raleigh
Wilmington
Norfolk
Richmond
Washington
Baltimore
Philadelphia
Atlantic City
Cape May

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, December, 1924




4 a.m.
5 a.m.
6 a.m.
7 a.m.
8 a.m.
9 a.m.
Barkerville
Edmonton
Battleford
Prince Albert
The Pas
Calgary
Medicine Hat
Qu'Appelle
Swift Current
Minnedosa
Winnipeg
Kamloops
Spokane
Rathdrum
Wallace
Missoula
Helena
Billings
Miles City
Williston
Devils Lake
Grand Forks
Fargo
Moorhead
Duluth
Bismarck
Minneapolis
St. Paul
Pierre
Huron
Rapid City
Sioux City
Omaha
Des Moines
Chicago
La Salle
Davenport
Peoria
Fort Wayne
Madison
Milwaukee
Dubuque
Green Bay
La Crosse
Grand Haven
Ludington
Saginaw
Detroit
Lansing
Toledo
Cleveland
Erie
Buffalo
Rochester
Albany
Toronto
Oswego
Syracuse
Sault Ste Marie
Parry Sound
Stonecliffe
White River
Port Arthur
Cochrane
Father Point
Quebec
Chatham
Sydney
St. John
Portland
Boston
Concord
Burlington
Northfield
Eastport
Halifax
Bermuda
Cape Henry
Cape May
Atlantic City
Sandy Hook
Block Id
Harrisburg
Philadelphia
Baltimore
Washington
Richmond
Norfolk
Lynchburg
Staunton
Wytheville
Roanoke
Parkersburg
Ellenboro
Huntington
Cincinnati
Indianapolis
Terre Haute
Springfield
Columbus
Louisville
Lexington
Evansville
Cairo
Nashville
Knoxville
Asheville
Charlotte
Raleigh
Hatteras
Memphis
Little Rock
Vicksburg
Meridian
Montgomery
Macon
Savannah
Jacksonville
Apalachicola
Pensacola
Mobile
Thomasville
Columbia
Augusta
Atlanta
Birmingham
Anniston
Charleston
Tampa
Titusville
Miami
Nassau
Key West
Havana
Cienfuegos
Santiago de Cuba
Puerto Principe
Barrwood
New Orleans
Houston
Galveston
San Antonio
Taylor
Corpus Christi
Brownsville
Abilene
Fort Worth
Dallas
Shreveport
Palestine
Jackson
Austin
Amarillo
Oklahoma
Muskogee
Fort Smith
Bentonville
Springfield
Topeka
Kansas City
St. Louis
Columbia
Concordia
St. Joseph
Hannibal
Kearney
Grand Island
North Platte
Lincoln
Omaha
Sioux City
Pierre
Huron
Rapid City
Pocatello
Ogden
Salt Lake City
Grand Junction
Denver
Pueblo
Dodge City
Wichita
Iola
Leadville
Cheyenne
Lander
Billings
Miles City
Helena
Missoula
Spokane
Walla Walla
Wallace
Rathdrum
Kamloops
Barkerville
Roseburg
Eugene
Portland
Astoria
North Head
Tatoosh Island
Seattle
Port Angeles
Victoria
Mount Tamalpais
San Francisco
Fresno
Tonopah
Independence
Modena
Los Angeles
San Diego
Yuma
Phoenix
Tucson
Flagstaff
Santa Fe
Roswell
El Paso
Albuquerque
Winnemucca
Red Bluff
Eureka
Boise
Baker
Pendleton
The Dalles
Walla Walla
Spokane
Rathdrum
Wallace
Missoula
Helena
Billings
Miles City
Williston
Devils Lake
Grand Forks
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Cleveland
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Buffalo
Rochester
Albany
Toronto
Oswego
Syracuse
Sault Ste Marie
Parry Sound
Stonecliffe
White River
Port Arthur
Cochrane
Father Point
Quebec
Chatham
Sydney
St. John
Portland
Boston
Concord
Burlington
Northfield
Eastport
Halifax
Bermuda
Cape Henry
Cape May
Atlantic City
Sandy Hook
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Harrisburg
Philadelphia
Baltimore
Washington
Richmond
Norfolk
Lynchburg
Staunton
Wytheville
Roanoke
Parkersburg
Ellenboro
Huntington
Cincinnati
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Springfield
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Evansville
Cairo
Nashville
Knoxville
Asheville
Charlotte
Raleigh
Hatteras
Memphis
Little Rock
Vicksburg
Meridian
Montgomery
Macon
Savannah
Jacksonville
Apalachicola
Pensacola
Mobile
Thomasville
Columbia
Augusta
Atlanta
Birmingham
Anniston
Charleston
Tampa
Titusville
Miami
Nassau
Key West
Havana
Cienfuegos
Santiago de Cuba
Puerto Principe
Barrwood
New Orleans
Houston
Galveston
San Antonio
Taylor
Corpus Christi
Brownsville
Abilene
Fort Worth
Dallas
Shreveport
Palestine
Jackson
Austin
Amarillo
Oklahoma
Muskogee
Fort Smith
Bentonville
Springfield
Topeka
Kansas City
St. Louis
Columbia
Concordia
St. Joseph
Hannibal
Kearney
Grand Island
North Platte
Lincoln
Omaha
Sioux City
Pierre
Huron
Rapid City
Pocatello
Ogden
Salt Lake City
Grand Junction
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Flagstaff
Santa Fe
Roswell
El Paso
Albuquerque
Winnemucca
Red Bluff
Eureka
Boise
Baker
Pendleton
The Dalles
Walla Walla
Statute Miles
Kilometers
D.

(Plotted by F. A. Young)

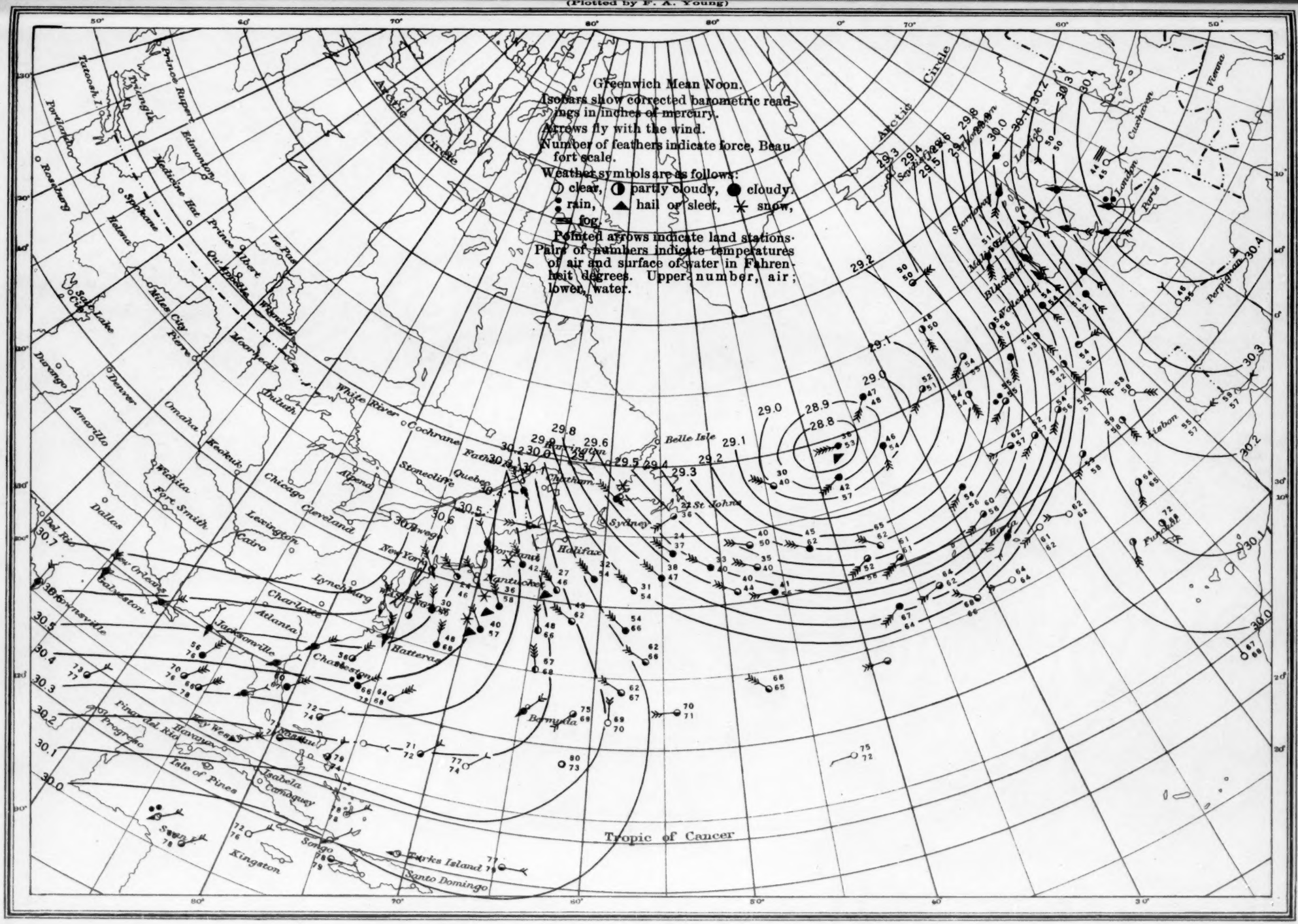
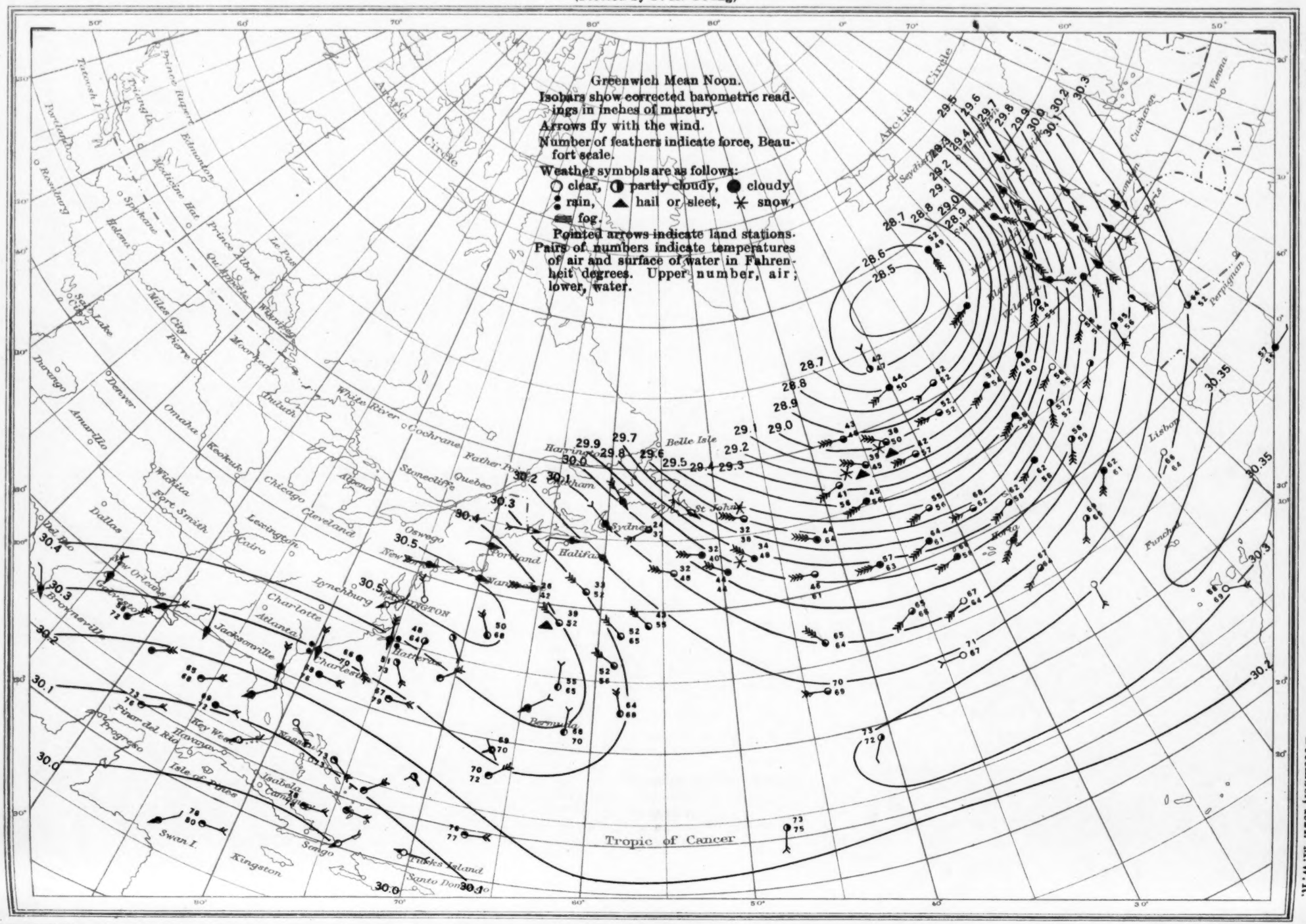


Chart IX. Weather Map of North Atlantic Ocean, December 22, 1924

(Plotted by F. A. Young)


Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail or sleet, snow,
fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.
Tropic of Cancer

(Plotted by F. A. Young)

(Plotted by F. A. Young)

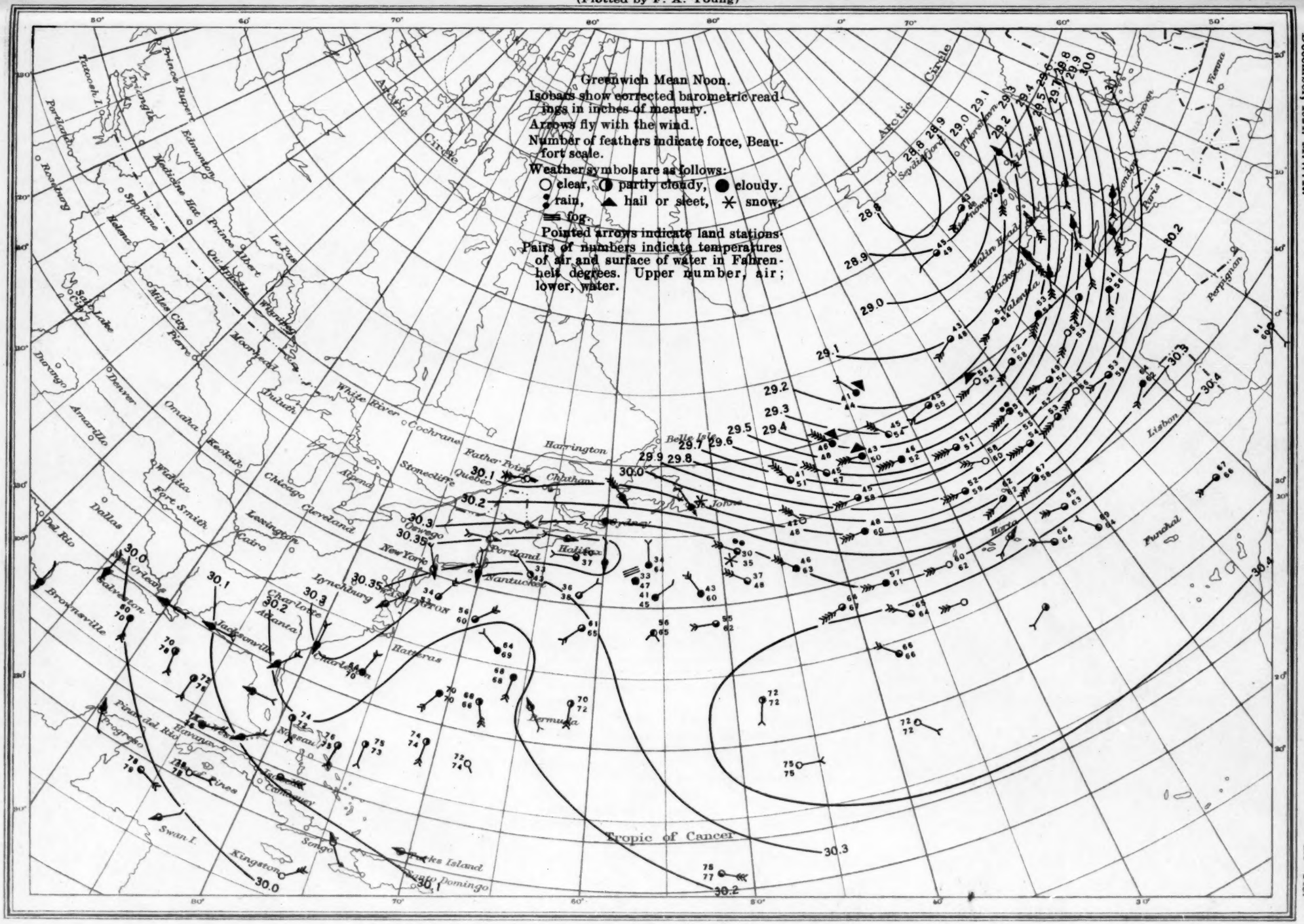
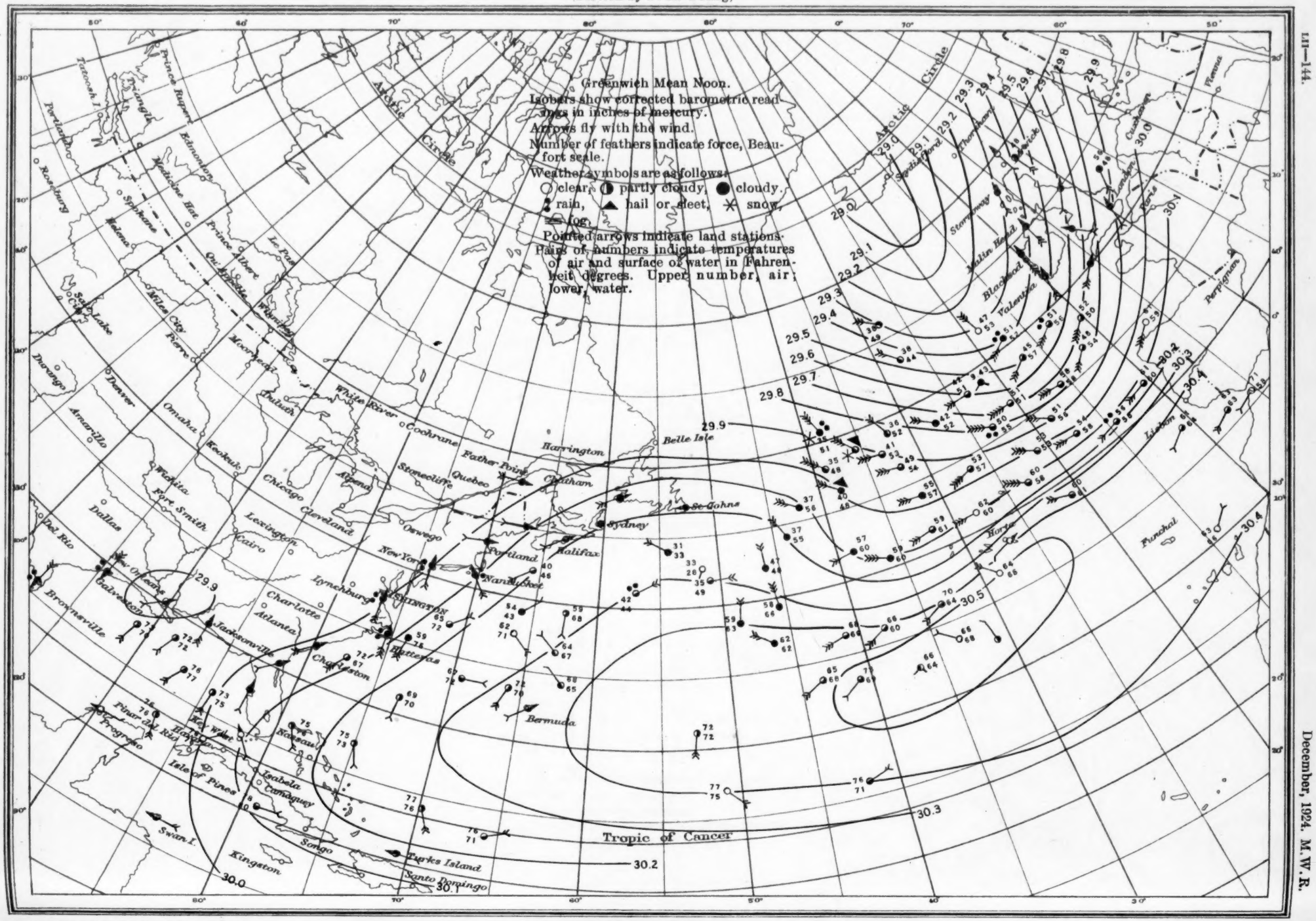


Chart XI. Weather Map of North Atlantic Ocean, December 24, 1924

(Plotted by F. A. Young)



(Plotted by F. A. Young)

December, 1924. M.W.R.

(Plotted by F. A. Young)

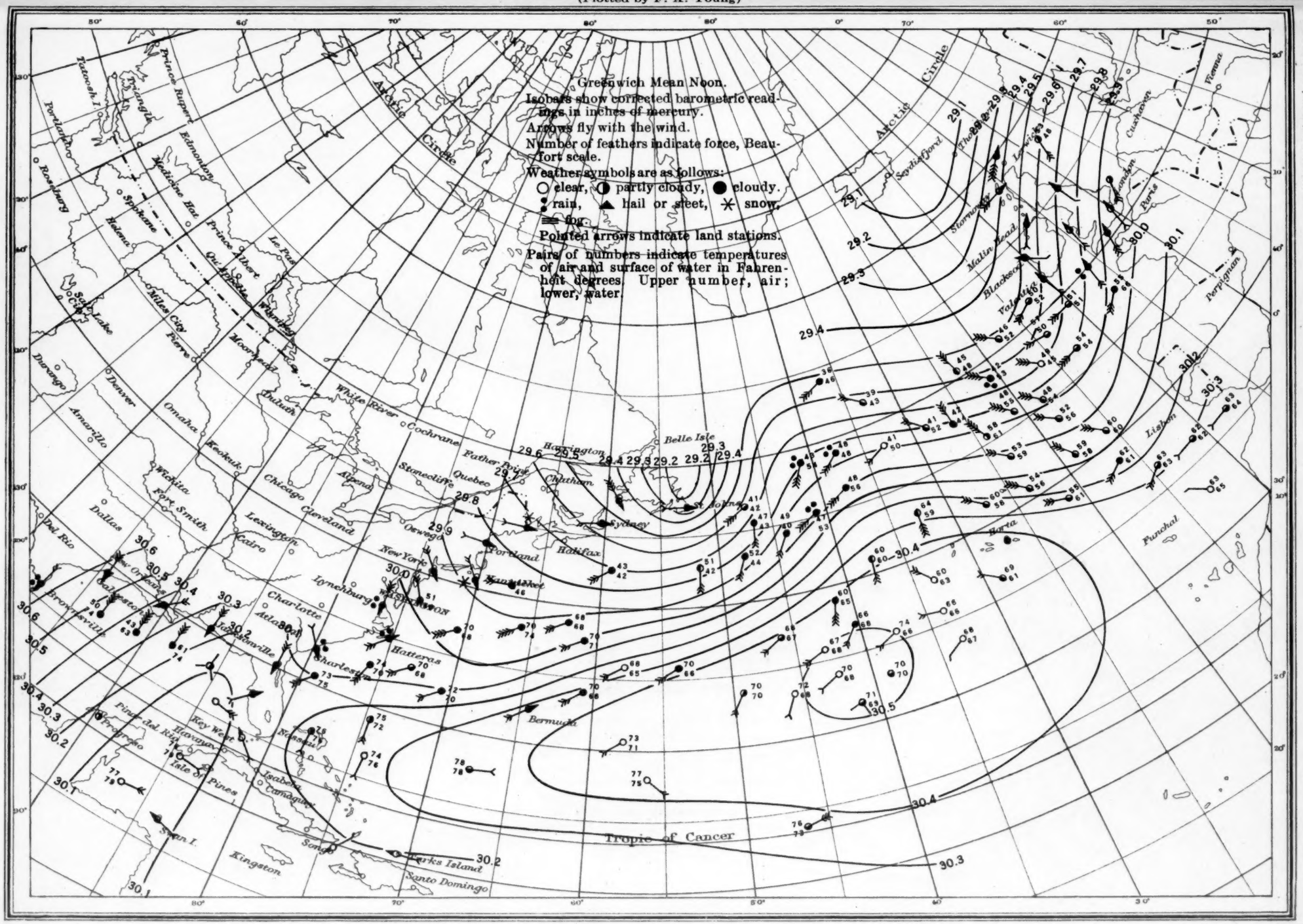
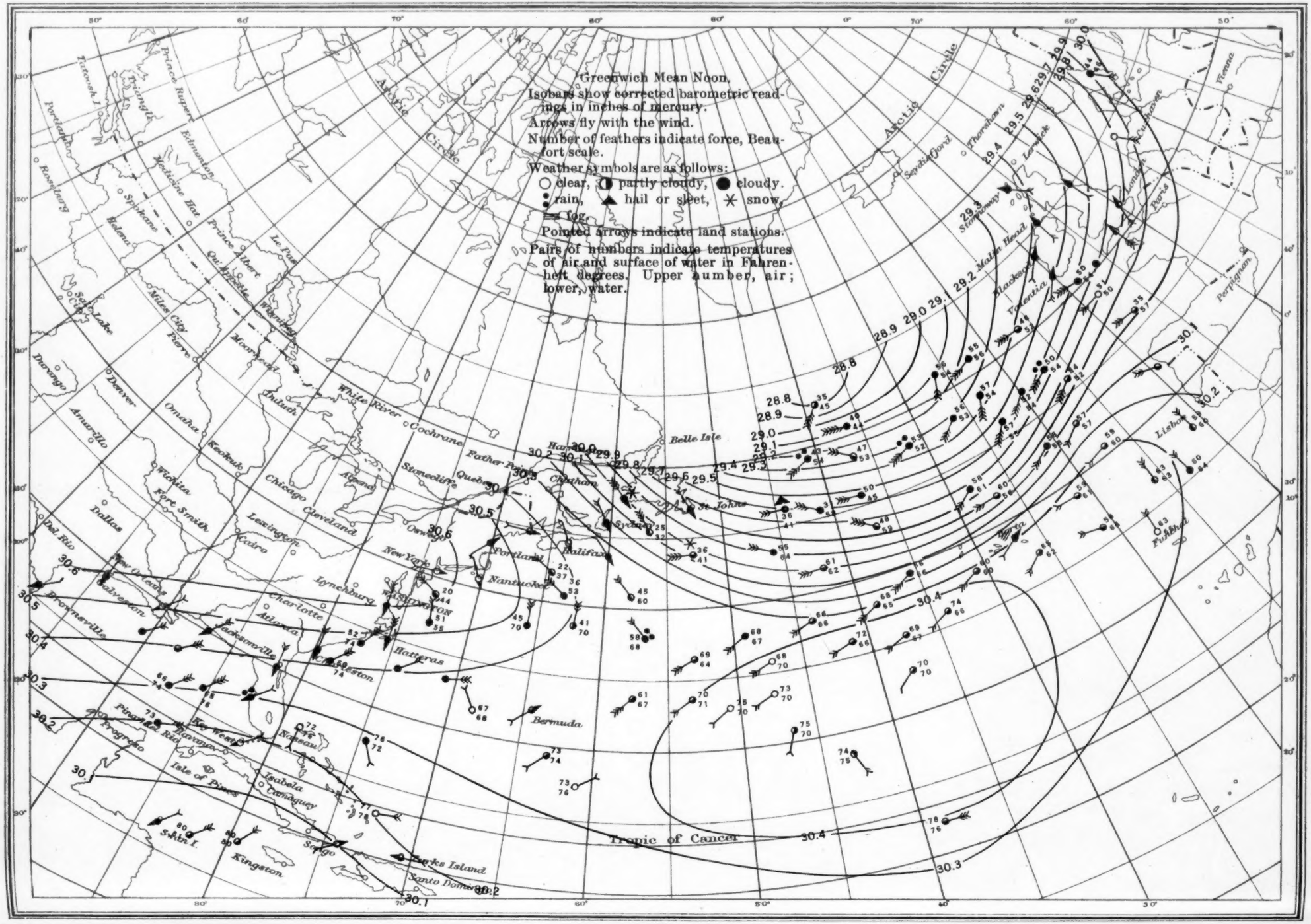


Chart XIII. Weather Map of North Atlantic Ocean, December 26, 1924

(Plotted by F. A. Young)


Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy.
rain, hail or sleet, snow,
fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.
Arctic Circle
Tropic of Cancer
Belle Isle
Cochrane
Father Point
Quebec
Chatham
St. John
Sydney
Halifax
Portland
Nantucket
New York
Washington
Hatteras
Bermuda
Nassau
Charleston
Jacksonville
Atlanta
Charlotte
Lynchburg
Cleveland
Chicago
Omaha
Duluth
White River
Moorhead
Pierre
Miles City
Medicine Hat
Edmonton
Prince Albert
Prince Rupert
Dodge City
Wichita
Fort Smith
Kansas City
Cairo
Lexington
Dallas
Del Rio
Galveston
New Orleans
Brownsville
Key West
Havana
Isle of Pines
Isabela
Caibarien
Santiago
Kingston
Port au Prince
Santo Domingo
Turks Island
Progreso
Belize
Spokane
Helena
Roseburg
Denver
Amarillo
Durango
Seattle
Triangle
Tatoosh I.
Portland
Lake
Sault Ste. Marie
Winnipeg
Le Pas
Swift Current
Qu'Appelle
Prince Albert
Battleford
Edmonton
Medicine Hat
Calgary
Prince Rupert
Triangle
Tatoosh I.
Roseburg
Portland
Spokane
Helena
Miles City
Pierre
Moorhead
Duluth
Omaha
Denver
Amarillo
Durango
Dodge City
Wichita
Fort Smith
Kansas City
Cairo
Lexington
Dallas
Del Rio
Galveston
New Orleans
Brownsville
Key West
Havana
Isle of Pines
Isabela
Caibarien
Santiago
Kingston
Port au Prince
Santo Domingo
Turks Island
Progreso
Belize
Nassau
Bermuda
Hatteras
Charleston
Jacksonville
Atlanta
Charlotte
Lynchburg
Cleveland
Chicago
Omaha
Duluth
White River
Moorhead
Pierre
Miles City
Medicine Hat
Edmonton
Prince Albert
Prince Rupert

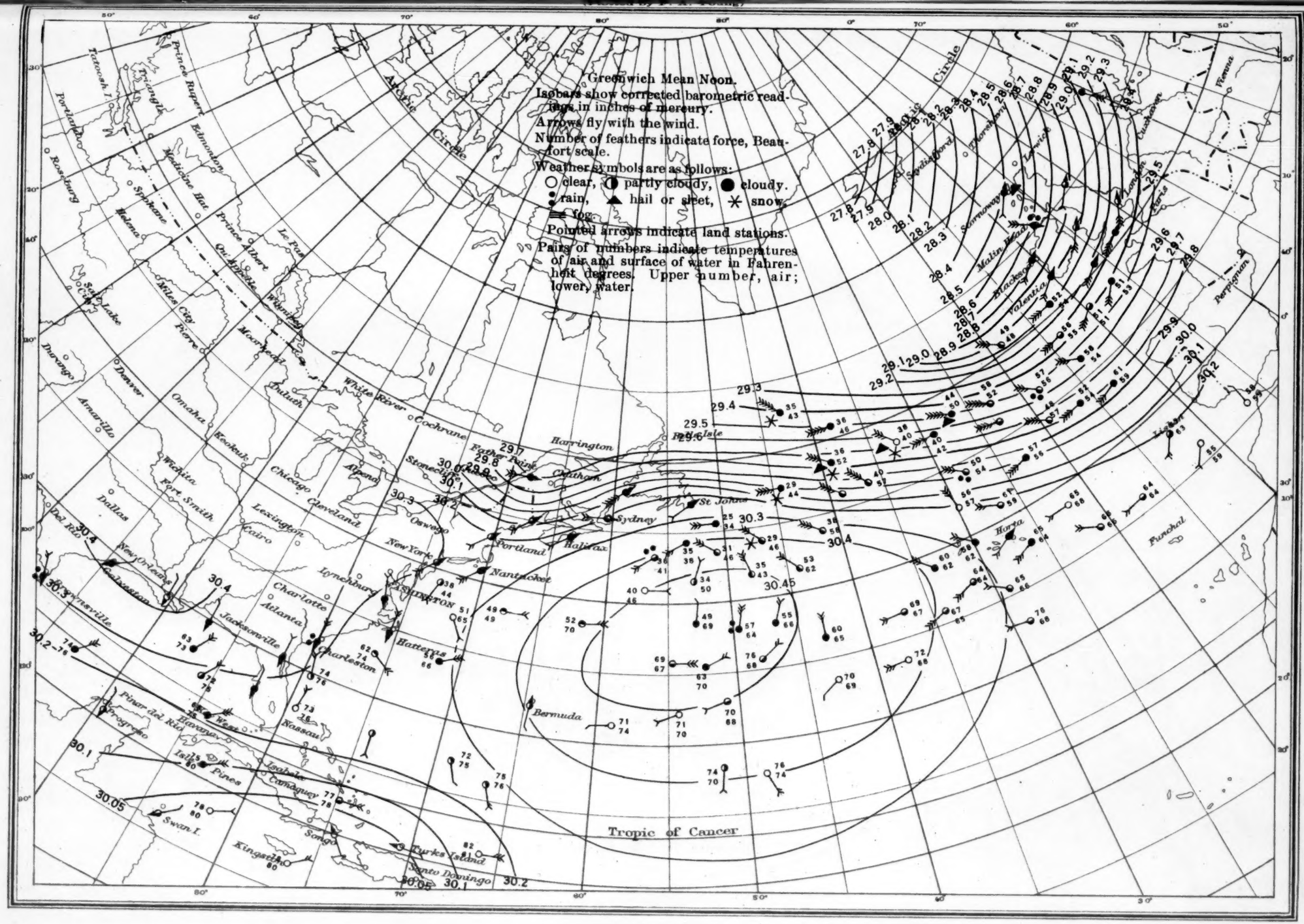

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy.
rain, hail or sleet, snow.
fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.
Tropic of Cancer
Arctic Circle
Prince Rupert
Edmonton
Medicine Hat
Prince Albert
Winnipeg
Moosejaw
Duluth
White River
Cochrane
Father Point
Harrington
Chatham
Stonecliffe
Toronto
Alpena
Chicago
Cleveland
Oswego
Portland
Halifax
St. John's
Sydney
New York
Nantucket
Lynchburg
Washington
Hatteras
Charlotte
Atlanta
Jacksonville
Charleston
Lexington
Cairo
Omaha
Keokuk
Dallas
Fort Smith
Wichita
Amarillo
Denver
Pierre
Miles City
Helena
Spokane
Roseburg
Portland
Tatoosh I.
Galveston
New Orleans
Del Rio
Brownsville
Progreso
Havana
Pinar del Rio
Isle of Pines
Nassau
Isabela
Camaguey
Swan I.
Kingston
Santo Domingo
Turks Island
Bermuda
Horta
Funchal
Lerwick
Stornoway
Malin Head
Blacksod Pt.
Valentia
Scilly
Holyhead
Aberdeen
Yarmouth
Sydney
Flamborough
Spurn Head
Sandettie
Gt. Yarmouth
Dunkirk
Ushant
Jersey
Guernsey
Cherbourg
Le Havre
Paris
Perpignan
Tarifa
Gibraltar
Malaga
Valencia
Barcelona
Tripoli
Malta
Tunis
Algiers
Oran
Gabes
Biskra
Ghadames
Tamanrasset
Timbuktu
Bathurst
Freetown
Monrovia
Accra
Lagos
Bonny
Duala
Libreville
Loanda
Mossamedes
Walvis Bay
Cape Town
Port Elizabeth
East London
Durban
Lourenco Marques
Beira
Tete
Salisbury
Bulawayo
Francistown
Windhoek
Kimberley
Johannesburg
Pretoria
Mafeking
Victoria Falls
Broken Hill
Kalgoorlie
Perth
Geraldton
Carnarvon
Cossack
Port Hedland
Broome
Wyndham
Darwin
Thursday I.
Port Darwin
Normanton
Cloncurry
Mt. Isa
Camooweal
Burketown
Brisbane
Rockhampton
Townsville
Cairns
Thursday I.
Port Moresby
Samarai
Rabaul
Kavieng
Manila
Hongkong
Amoy
Shanghai
Nagasaki
Fusan
Seoul
Vladivostok
Nikolaevsk
Petropavlovsk
Ostrovnoe
Nome
Dutch Harbor
Kodiak
Sitka
Juneau
Prince Rupert
Tatoosh I.
Portland
Roseburg
Spokane
Helena
Miles City
Pierre
Moosejaw
Winnipeg
Duluth
Omaha
Keokuk
Chicago
Cleveland
Oswego
Portland
Halifax
St. John's
Sydney
Harrington
Chatham
Father Point
Cochrane
White River
Moosejaw
Winnipeg
Prince Albert
Edmonton
Medicine Hat
Prince Rupert
Tatoosh I.
Portland
Roseburg
Spokane
Helena
Miles City
Pierre

Chart XV. Paths of Hurricanes and Other Tropical Storms, 1924

(Approximate position at each observation hour)

(Plotted by W. P. Day)